JEE

Advanced With Main

48 + 143

Years (2025-1978)

Sets (2025-2019)

WITH RESPONSE TAGGING

Analyse the question-wise difficulty level in real-time with Correct (C), Wrong (W) and Unattempted (UA) questions response tagging provided by IIT-JEE

CHEMISTRY

Chapter-wise & Topic-wise Solved Papers

ANSWER KEY VERIFIED FROM OFFICIAL ANSWER KEYS

JEE

Advanced With Main

48 + 143

Years (2025-1978) | Sets (2025-2019)

CHEMISTRY

CHAPTER-WISE & TOPIC-WISE SOLVED PAPERS

ANSWER KEY VERIFIED FROM OFFICIAL ANSWER KEYS

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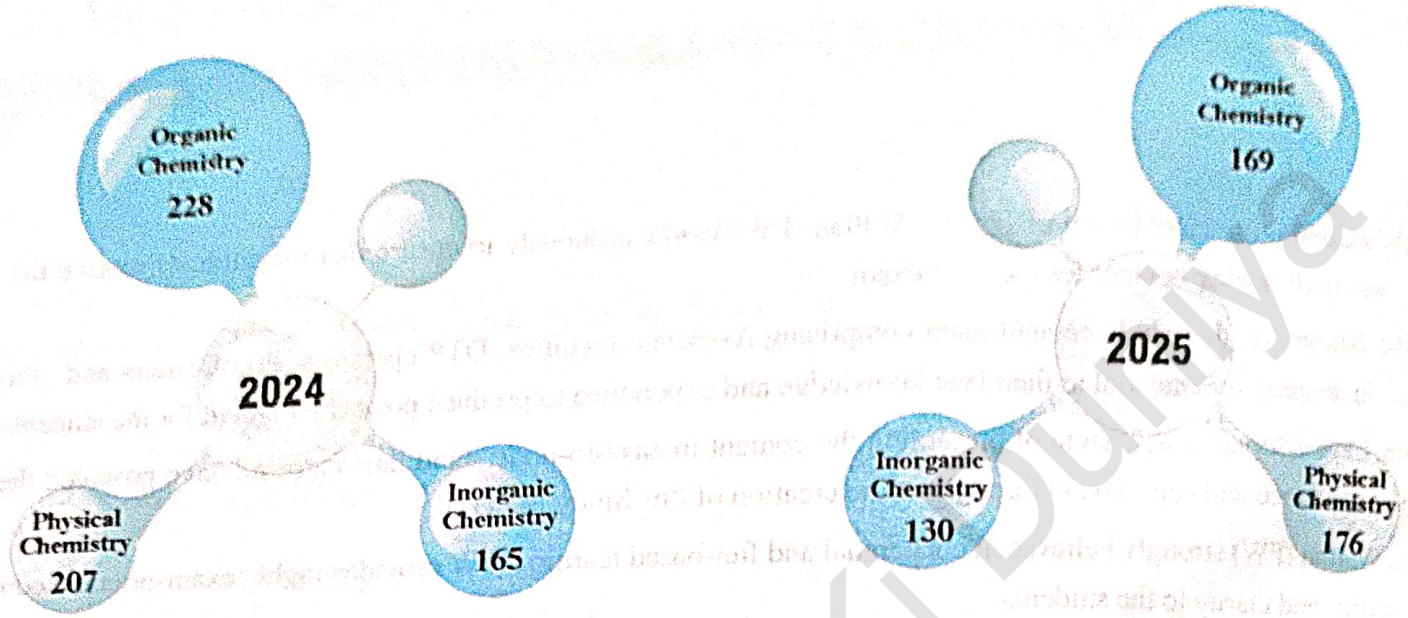
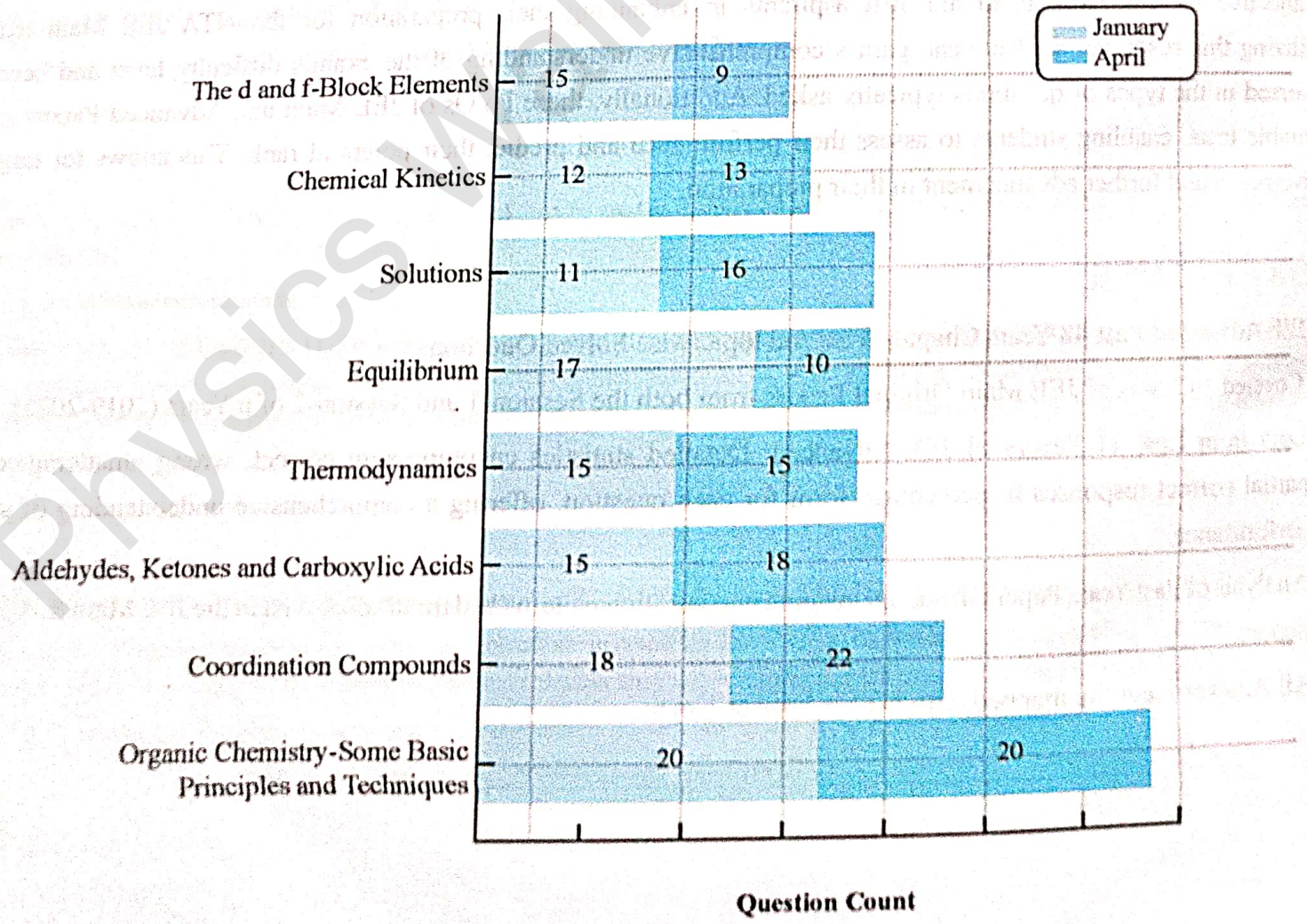
JEE MAIN 2025 Paper Analysis

Subdicipline Question Trends



Major Chemistry Chapters (>> 50% Weightage)



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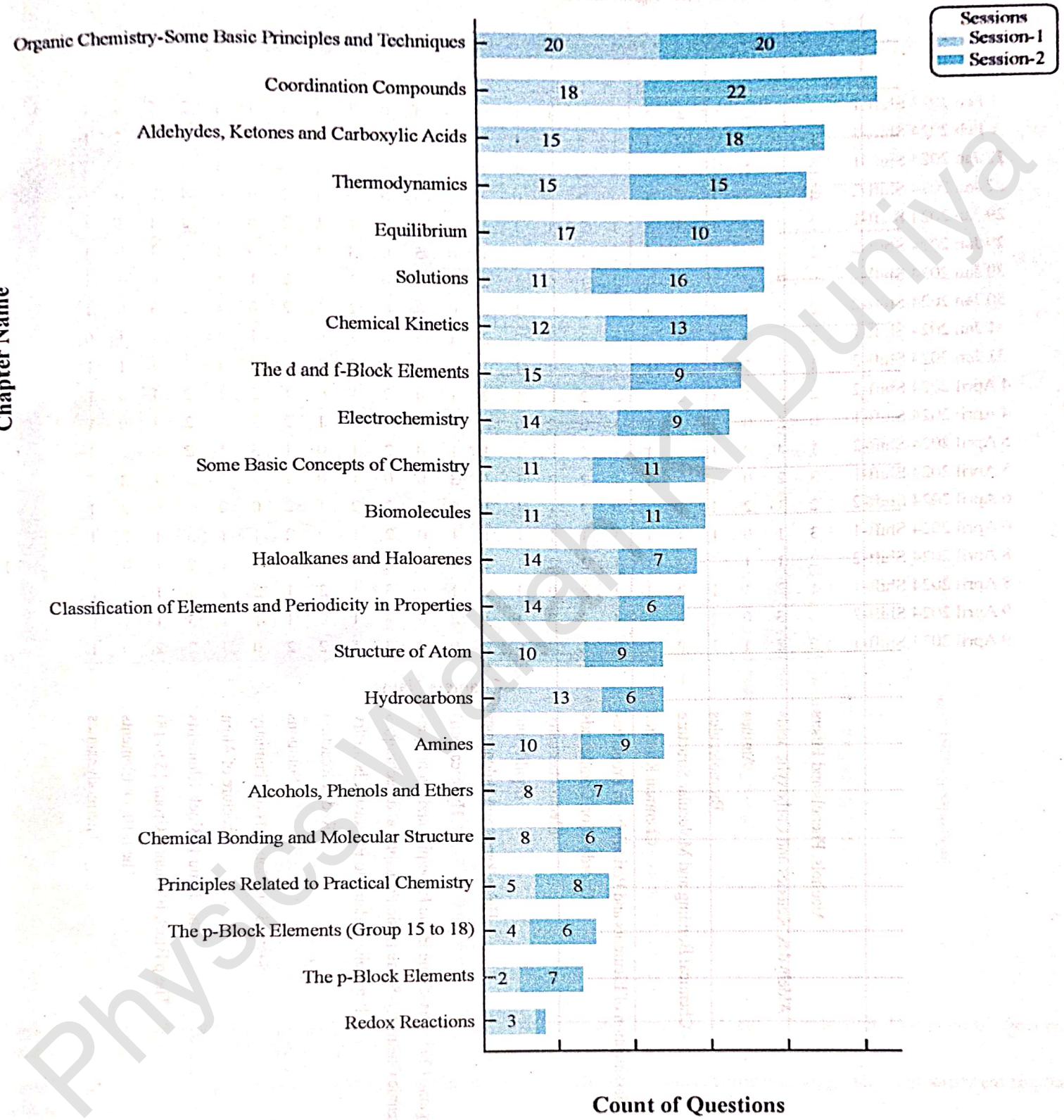
Chapter Count Per Session-2025



Focus on Organic Chemistry: The chapter "Organic Chemistry-Some Basic Principles and Techniques" stands out with the highest question count in both sessions, highlighting its central role.

Session Variability: Topics like "Thermodynamics" and "Equilibrium" show notable differences between sessions, indicating shifts in focus.

Combined Insights for 2023 and 2024

Trending Topics: There's an increase in emphasis on "Organic Chemistry" and "The d and f-Block Elements" in 2024 compared to 2023.

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Heatmap of Chapter Occurences Across Different Paper Sessions-2025

Paper Sessions	Alcohols, Phenols and Ethers	Aldehydes, Ketones and Carboxylic acids	Amines	Biomolecules	Chemical Bonding and Molecular Structure	Chemical Kinetics	Classification of Elements and Periodicity in Properties	Coordination Compounds	Electrochemistry	Equilibrium	Haloalkanes and Haloarenes	Hydrocarbons	Organic Chemistry-Some Basic Principles and Techniques	Redox Reaction	Solutions	Some Basic Concepts of Chemistry	Structure of Atom	The d and f-Block Elements	The p Block Elements (Group 15 to 18)	The p-Block Elements	Thermodynamics	Principles Related to Practical Chemistry
02 Apr 2025 Shift-1	0	2	1	1	1	1	0	2	1	2	1	1	1	0	2	3	1	0	1	2	1	1
02 Apr 2025 Shift-2	0	1	1	1	1	2	1	2	1	1	2	1	4	0	2	0	1	1	0	1	2	0
03 Apr 2025 Shift-1	0	2	2	1	0	1	1	3	1	2	0	0	4	0	1	1	1	1	0	1	2	1
03 Apr 2025 Shift-2	0	1	1	2	0	1	1	1	1	0	1	0	5	0	1	1	1	2	1	0	3	2
04 Apr 2025 Shift-1	1	3	1	2	1	2	0	2	1	1	1	0	1	0	2	0	1	1	1	1	2	1
04 Apr 2025 Shift-2	1	2	1	1	1	2	0	3	1	1	1	1	2	0	2	1	1	1	2	0	1	0
07 Apr 2025 Shift-1	2	1	1	1	1	2	0	2	1	1	0	1	1	0	2	2	1	2	1	0	1	2
07 Apr 2025 Shift-2	1	3	1	1	1	1	2	4	1	1	0	2	1	0	2	1	0	0	1	0	2	0
08 Apr 2025 Shift-2	2	3	0	1	0	1	1	3	1	1	1	0	1	0	2	2	2	1	0	1	1	1
22 Jan 2025 Shift-1	0	1	2	1	1	2	2	2	2	1	1	2	3	0	1	1	1	1	0	0	1	0
22 Jan 2025 Shift-2	0	1	1	1	1	1	1	3	1	1	2	2	2	1	1	1	1	1	0	1	2	0
23 Jan 2025 Shift-1	1	1	2	1	1	1	1	3	1	2	2	1	2	0	0	1	1	1	0	1	2	0
23 Jan 2025 Shift-2	2	1	1	1	0	1	1	1	1	2	1	2	0	0	2	2	1	2	1	0	2	1
24 Jan 2025 Shift-1	1	3	0	1	1	0	2	1	1	4	1	1	2	0	1	1	0	2	0	0	2	1
24 Jan 2025 Shift-2	0	1	1	1	1	2	2	2	1	2	1	2	3	0	1	1	1	1	0	0	1	1
28 Jan 2025 Shift-1	0	3	0	1	1	1	1	0	1	2	3	0	1	1	1	2	1	3	1	0	1	1
28 Jan 2025 Shift-2	0	1	1	2	1	2	1	1	1	1	2	1	2	0	1	1	1	2	0	1	2	1
29 Jan 2025 Shift-1	3	1	1	1	0	1	2	2	3	1	0	1	2	0	2	1	1	2	0	0	1	0
29 Jan 2025 Shift-2	1	2	1	1	1	1	1	3	2	1	1	1	3	1	1	0	2	0	0	1	1	0

Chapters Name

High Frequency Chapters: "Organic Chemistry-Some Basic Principles and Techniques" and "Coordination Compounds" frequently appear across multiple sessions, indicating their significant importance.

Variable Distribution: Chapters like "Amines" and "Redox Reactions" show sporadic occurrences, suggesting less consistent emphasis in the examination schedule.

Physics Wallah Aryan Kumar

JEE ADVANCED 2025 Paper Analysis

Paper 1

Section	Question Type	No. of Questions	Marks per Question	Negative marks per question	Total Marks (Section wise)
1	Single Correct MCQs	4	3	–1	12
2	More than One Correct MCQs	3	4	–2	12
3	Non Negative Integer Type Questions	6	4	0	24
4	Matrix Type Questions	3	4	–1	12
	Total Questions per subject	16			60

Paper 2

Section	Question Type	No. of Questions	Marks per Question	Negative marks per question	Total Marks (Section wise)
1	Single Correct MCQs	4	3	–1	12
2	More than One Correct MCQs	4	4	–2	16
3	Numerical Value Based Questions	8	4	0	32
	Total Questions per subject	16			60

Total No. of Questions in Part 1 = 48 Questions
Total No. of Questions in Part 2 = 48 Questions
Each Subject Carries = 60 Marks
Total Marks = 180

Paper Analysis

Paper Difficulty Compared to Last Year	Almost similar to 2024 Paper
Overall Difficulty Level of JEE 2025	
Easy	38%
Moderate	53%
Difficult	9%

Chemistry Topics	Paper 1 Difficulty Level	Paper 2 Difficulty Level	Comments/Remarks	
Physical	Paper 1 almost similar compared to last year	Paper 2 easy to moderate compared to last year		No questions from chapters-some basic concepts of chemistry, atomic structure and redox reactions.
Inorganic	Almost similar	Almost similar	Only 3 questions from inorganic have been asked in 2025 Paper 2	No questions from chapter-classification of elements & periodicity in properties
Organic	Almost similar	Tougher to moderate		Combined topic Questions: 1 Medium question from [Polymers+Amines+GOC and 1 hard question from [Hydrocarbons Aldehydes + Haloalkanes + Ether]

Overall Analysis

Paper Difficulty Compared to Last Year

Easy to moderate
Unequal distribution among Physical, Organic, Inorganic
in paper 1, slightly more Questions from Inorganic
in paper 2, slightly more Questions from Physical
1 question from paper 1 from organic chemistry was tough
2 questions in paper 1 were a bit tricky
5 questions from Paper 1 and 4 Question from paper 2 were very easy
Rest of the questions were moderate
Chemistry will decide the rank

Physics Wallah Ki Duniya

JEE ADVANCED-6 Year (2024-19) Paper Analysis

Note: Due to unavailability of 2025 paper data we are unable to incorporate the 2025 analysis. As we are coming up with this book before the 2025 result.

Explanation of ★Unique★ Feature

C – Correct, W – Wrong, UA – Unattempted, PC – Partial Correct

C-31 W-22 UA-10 PC-36 represents the % of distribution of correct, wrong, unattempted and partial correct responses by students at any specific question in real time.(Data is taken from JEE Advanced website: https://jeeadv.ac.in/reports.html)

Classification helps students understand the varying **levels of difficulty**.

For Example

22. Which of the following statement(s) is (are) correct regarding the root mean square speed (U_{rms}) and average translational kinetic energy (E_{av}) of a molecule in a gas at equilibrium?

C-31 W-22 UA-10 PC-36 **(JEE Adv. 2019)**

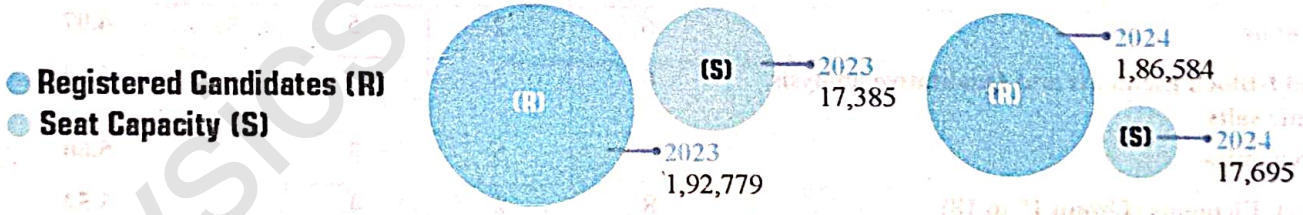
(*a*) U_{rms} is inversely proportional to the square root of its molecular mass

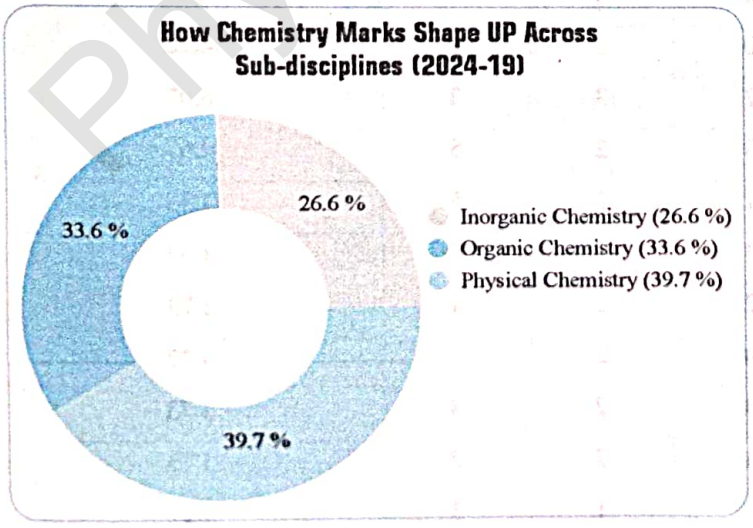
(*b*) U_{rms} is doubled when its temperature is increased four times

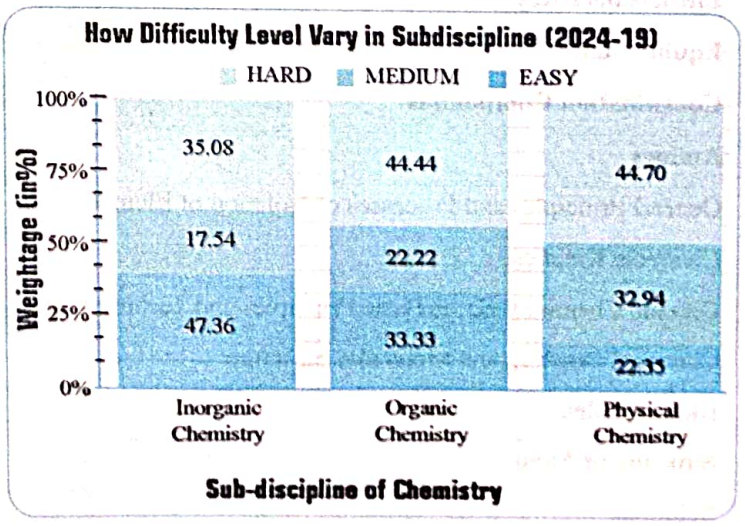
(*c*) E_{av} is doubled when its temperature is increased four times

(*d*) E_{av} at a given temperature does not depend on its molecular mass

Question is considered EASY as Correct response recorded was greater than 20%







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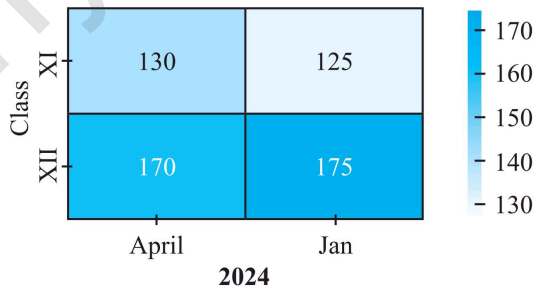
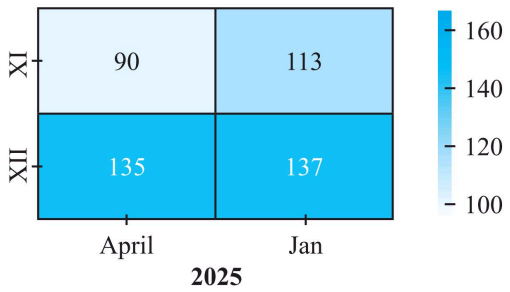
Chapter-wise Weightage Analysis

	Chapter Name	Jan	April
50% Questions Asked from these 8 chapters	Organic Chemistry-Some Basic Principles and Techniques	20	20
	Coordination Compounds	18	22
	Aldehydes, Ketones and Carboxylic Acids	15	18
	Thermodynamics	15	15
	Equilibrium	17	10
	Solutions	11	16
	Chemical Kinetics	12	13
	The d and f-Block Elements	15	9
	Electrochemistry	14	9
	Some Basic Concepts of Chemistry	11	11
	Biomolecules	11	11
	Haloalkanes and Haloarenes	14	7
	Classification of Elements and Periodicity in Properties	14	6
	Structure of Atom	10	9
	Hydrocarbons	13	6
	Amines	10	9
	Alcohols, Phenols and Ethers	8	7
	Chemical Bonding and Molecular Structure	8	6
	Principles Related to Practical Chemistry	5	8
	The p-Block Elements (Group 15 to 18)	4	6
	The p-Block Elements	2	7
	Redox Reactions	3	0

Class-wise Distribution of Question





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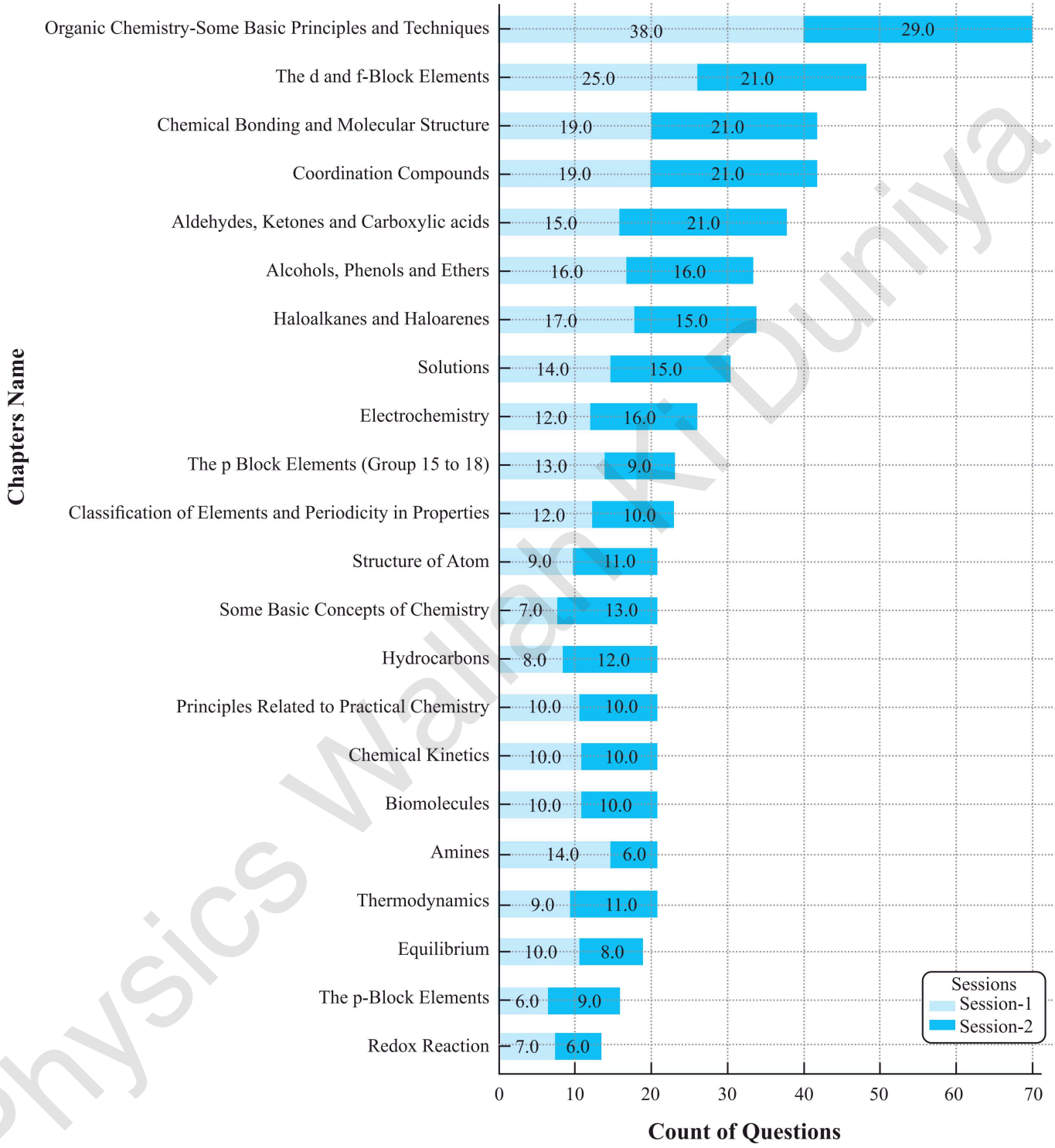
Chapters Count Per Session-2024



Focus Variability: The number of questions on "Coordination Compounds" increased from Session-1 to Session-2, indicating a shift in emphasis, while "The d and f-Block Elements" and "Solutions" saw a reduction.

Consistent Topics: Chapters like "Aldehydes, Ketones and Carboxylic Acids" and "Amines" had a consistent question count across sessions, suggesting their steady importance in the curriculum.

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JEE ADVANCED 2025 Paper Analysis

Paper 1

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Classification helps students understand the varying **levels of difficulty**.

Easy	Medium	Hard
C > 20%	10% < C ≤ 20%	C ≤ 10%

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C-31 W-22 UA-10 PC-36 (JEE Adv. 2019)

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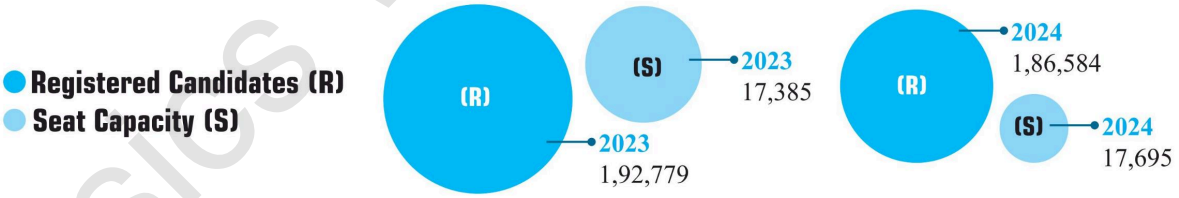

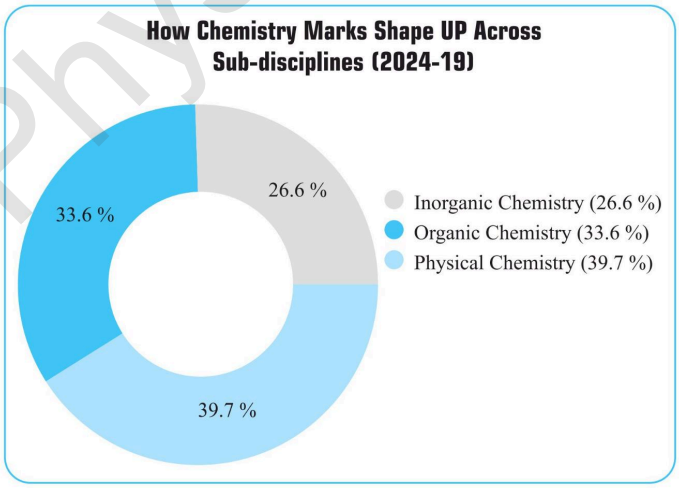

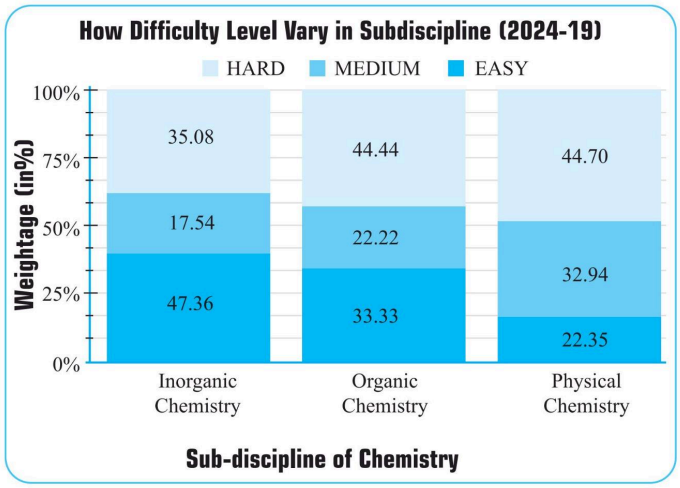

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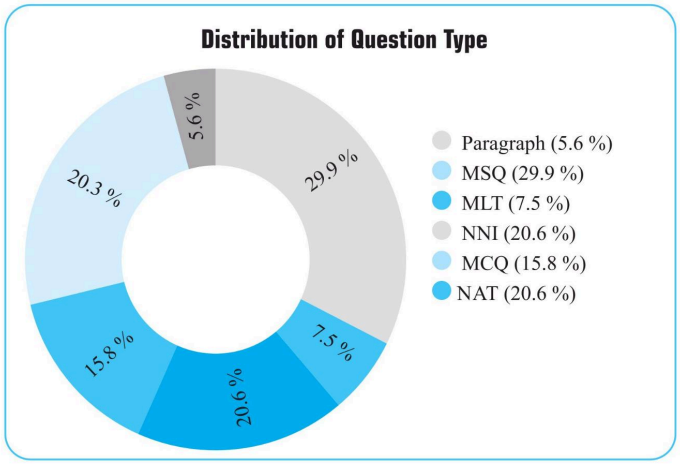

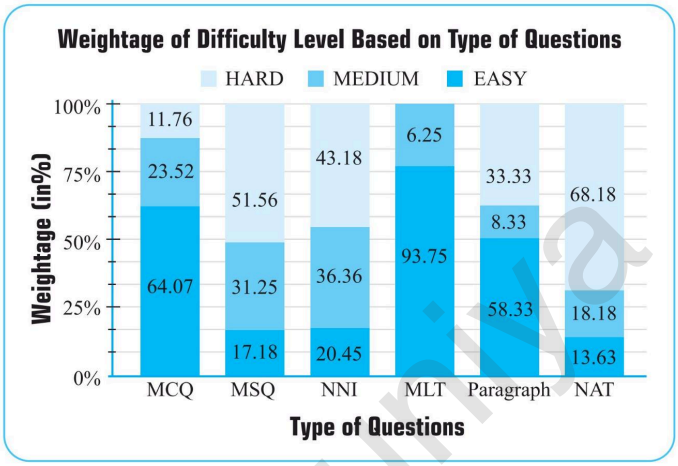

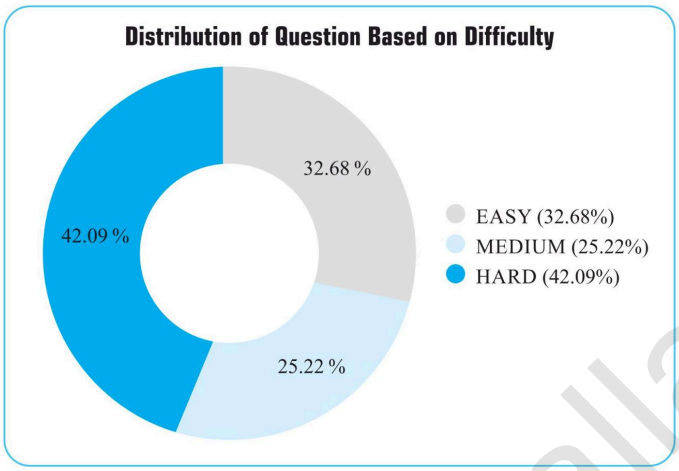

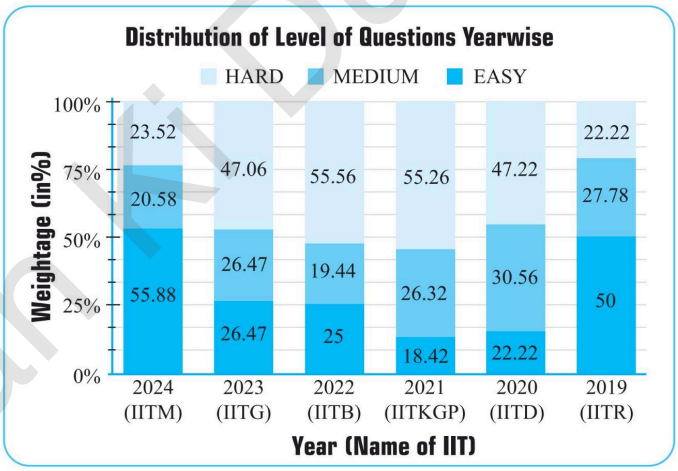

Chapter wise Weightage and count of Difficulty level of JEE Advanced Questions

Chapters Name	EASY	MEDIUM	HARD	Chapterwise Weightage(in %)
Aldehydes, Ketones and Carboxylic acids	6	4	10	**9.34**
Hydrocarbons	6	2	5	**6.07**
The d- and f-Block Elements and Qualitative analysis of Inorganic salts	6	3	5	**6.54**
Thermodynamics	0	5	7	**5.60**
The p-Block Elements (Group 15 to 18)	8	2	4	**6.54**
Electrochemistry	0	4	7	**5.14**
Equilibrium	0	2	7	**4.20**
Coordination Compounds	7	3	3	**6.07**
Amines	3	2	5	**4.67**
General Principles and Processes of Isolation of Elements	1	2	5	3.73
Chemical Kinetics	4	1	5	4.67
Organic Chemistry-Some Basic Principles and Techniques	2	2	4	3.73
Chemical Bonding and Molecular Structure	4	2	1	3.27
Biomolecules	3	2	3	3.73
Structure of Atom	4	2	2	3.73
Solutions	3	1	3	3.27

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7. Equilibrium 151-190
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29. Principles Related to Practical Chemistry 807-823

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2025

JEE Advanced Solved Paper

Chemistry Paper-1

SECTION 1 (Maximum Marks: 12)

- This section contains **FOUR (04)** questions.
- Each question has **FOUR** options (*a*), (*b*), (*c*) and (*d*). **ONLY ONE** of these four options is the correct answer.
- For each question, choose the option corresponding to the correct answer.
- Answer to each question will be evaluated according to the following marking scheme:

  Full Marks : +3 If **ONLY** the correct option is chosen;

  Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);

  Negative Marks : –1 In all other cases.

1. The heating of NH4NO2 at 60 –70° C and NH4NO3 at 200 –250°C is associated with the formation of nitrogen containing compounds X and Y, respectively. X and Y, respectively, are

(*a*) N_2 and N_2O (*b*) NH_3 and NO_2

(*c*) NO and N_2O (*d*) N_2 and NH_3

2. The correct order of the wavelength maxima of the absorption band in the ultraviolet-visible region for the given complexes is

(*a*) $[Co(CN)_6]^{3-} < [Co(NH_3)_6]^{3+} < [Co(NH_3)_5(H_2O)]^{3+} < [Co(NH_3)_5(Cl)]^{2+}$

(*b*) $[Co(NH_3)_5(Cl)]^{2+} < [Co(NH_3)_5(H_2O)]^{3+} < [Co(NH_3)_6]^{3+} < [Co(CN)_6]^{3-}$

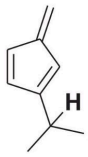
(*c*) $[Co(CN)_6]^{3-} < [Co(NH_3)_5(Cl)]^{2+} < [Co(NH_3)_5(H_2O)]^{3+} < [Co(NH_3)_6]^{3+}$

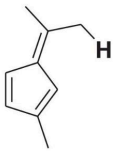
(*d*) $[Co(NH_3)_6]^{3+} < [Co(CN)_6]^{3-} < [Co(NH_3)_5(Cl)]^{2+} < [Co(NH_3)_5(H_2O)]^{3+}$

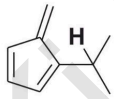
3. One of the products formed from the reaction of permanganate ion with iodide ion in neutral aqueous medium is

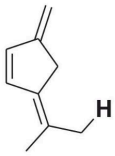
(*a*) I_2 (*b*) IO_3^- (*c*) IO_4^- (*d*) IO_2^-

4. Consider the depicted hydrogen (H) in the hydrocarbons given below. The most acidic hydrogen (H) is

(*a*) 

(*b*) 

(*c*) 

(*d*) 

SECTION 2 (Maximum Marks: 12)

- This section contains **THREE (03)** questions.
- Each question has **FOUR** options (*a*), (*b*), (*c*) and (*d*). **ONE OR MORE THAN ONE** of these four option(s) is(are) correct answer(s).
- For each question, choose the option(s) corresponding to (all) the correct answer(s).
- Answer to each question will be evaluated according to the following marking scheme:

  Full Marks : +4 **ONLY** if (all) the correct option(s) is(are) chosen;

  Partial Marks : +3 If all the four options are correct but **ONLY** three options are chosen;

  Partial Marks : +2 If three or more options are correct but **ONLY** two options are chosen, both of which are correct;

  Partial Marks : +1 If two or more options are correct but **ONLY** one option is chosen and it is a correct option;

  Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);

  Negative Marks: –2 In all other cases.
- For example, in a question, if (*a*), (*b*) and (*d*) are the **ONLY** three options corresponding to correct answers, then

  choosing ONLY (*a*), (*b*) and (*d*) will get +4 marks;

  choosing ONLY (*a*) and (*b*) will get +2 marks;

  choosing ONLY (*a*) and (*d*) will get +2 marks;

  choosing ONLY (*b*) and (*d*) will get +2 marks;

  choosing ONLY (*a*) will get +1 mark;

  choosing ONLY (*b*) will get +1 mark;

  choosing ONLY (*d*) will get +1 mark;

  choosing no option (i.e. the question is unanswered) will get 0 marks; and choosing any other combination of options will get –2 marks.

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5. Regarding the molecular orbital (MO) energy levels for homonuclear diatomic molecules, the **INCORRECT** statement(s) is(are)

(*a*) Bond order of Ne_2 is zero.

(*b*) The highest occupied molecular orbital (HOMO) of F_2 is σ-type.

(*c*) Bond energy of O_2^+ is smaller than the bond energy of O_2.

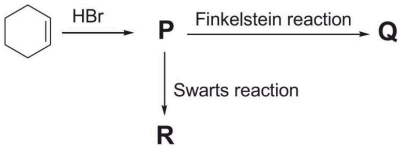
(*d*) Bond length of Li_2 is larger than the bond length of B_2.

6. The pair(s) of diamagnetic ions is(are)

(*a*) La^{3+}, Ce^{4+} (*b*) Yb^{2+}, Lu^{3+}

(*c*) La^{2+}, Ce^{3+} (*d*) Yb^{3+}, Lu^{2+}

7. For the reaction sequence given below, the correct statement (s) is(are)



(In the options, X is any atom other than carbon and hydrogen, and it is different in **P**, **Q** and **R**)

(*a*) C−X bond length in **P**, **Q** and **R** follows the order **Q** > **R** > **P**.

(*b*) C−X bond enthalpy in **P**, **Q** and **R** follows the order **R** > **P** > **Q**.

(*c*) Relative reactivity toward S_N2 reaction in **P**, **Q** and **R** follows the order **P** > **R** > **Q**.

(*d*) pK_a value of the conjugate acids of the leaving groups in **P**, **Q** and **R** follows the order **R** > **Q** > **P**.

SECTION 3 (Maximum Marks: 24)

- This section contains **SIX (06)** questions.
- The answer to each question is a **NON-NEGATIVE INTEGER**.
- For each question, enter the correct integer corresponding to the answer using the mouse and the on screen virtual numeric keypad in the place designated to enter the answer.
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks : +4 If **ONLY** the correct integer is entered;

Zero Marks : 0 In all other cases.

8. In an electrochemical cell, dichromate ions in aqueous acidic medium are reduced to Cr^{3+}. The current (in amperes) that flows through the cell for 48.25 minutes to produce 1 mole of Cr^{3+} is _____.

Use: 1 Faraday = 96500 C mol^{-1}

9. At 25°C, the concentration of H^+ ions in 1.00×10^{-3} M aqueous solution of a weak monobasic acid having acid dissociation constant (K_a) of 4.00×10^{-11} is **X** × 10^{-7} M. The value of **X** is _____.

Use: Ionic product of water (K_w) = 1.00×10^{-14} at 25°C

10. Molar volume (V_m) of a van der Waals gas can be calculated by expressing the van der Waals equation as a cubic equation with V_m as the variable. The ratio (in mol dm^{-3}) of the coefficient of V_m^2 to the coefficient of V_m for a gas having van der Waals constants a = 6.0 dm^6 atm mol^{-2} and b = 0.060 dm^3 mol^{-1} at 300 K and 300 atm is _____.

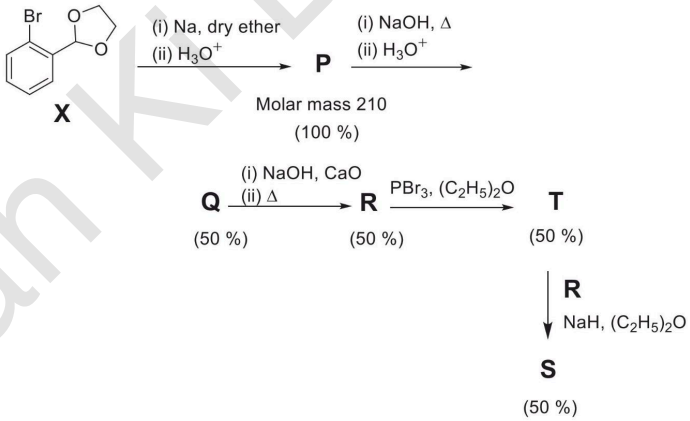
11. Considering ideal gas behavior, the expansion work done (in kJ) when 144 g of water is electrolyzed completely under constant pressure at 300 K is _____.

Use: Universal gas constant (R) = 8.3 J K^{-1} mol^{-1}; Atomic mass (in amu): H = 1, O = 16

12. The monomer (X) involved in the synthesis of Nylon 6,6 gives positive carbylamine test. If 10 moles of X are analyzed using Dumas method, the amount (in grams) of nitrogen gas evolved is _____.

Use: Atomic mass of N (in amu) = 14

13. The reaction sequence given below is carried out with 16 moles of X. The yield of the major product in each step is given below the product in parentheses. The amount (in grams) of S produced is_____.



Use: Atomic mass (in amu): H = 1, C = 12, O = 16, Br = 80

SECTION 4 (Maximum Marks: 12)

- This section contains **FOUR (04)** Matching List Sets.
- Each set has **ONE** Multiple Choice Question.
- Each set has **TWO** lists: **List-I** and **List-II**.
- **List-I** has **Four** entries (P), (Q), (R) and (S) and **List-II** has **Five** entries (1), (2), (3), (4) and (5).
- **FOUR** options are given in each Multiple Choice Question based on **List-I** and **List-II** and **ONLY ONE** of these four options satisfies the condition asked in the Multiple Choice Question.
- Answer to each question will be evaluated according to the following marking scheme:

Full Marks : +3 **ONLY** if the option corresponding to the correct combination is chosen;

Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);

Negative Marks : −1 In all other cases.

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14. The correct match of the group reagents in List-I for precipitating the metal ion given in List-II from solutions, is

	List - I		List - II
(P)	Passing H_2S in the presence of NH_4OH	(1)	Cu^{2+}
(Q)	$(NH_4)_2CO_3$ in the presence of NH_4OH	(2)	Al^{3+}
(R)	NH_4OH in the presence of NH_4Cl	(3)	Mn^{2+}
(S)	Passing H_2S in the presence of dilute HCl	(4)	Ba^{2+}
		(5)	Mg^{2+}

(*a*) (P) → (3); (Q) → (4); (R) → (2); (S) → (1)

(*b*) (P) → (4); (Q) → (2); (R) → (3); (S) → (1)

(*c*) (P) → (3); (Q) → (4); (R) → (1); (S) → (5)

(*d*) (P) → (5); (Q) → (3); (R) → (2); (S) → (4)

15. The major products obtained from the reactions in **List-II** are the reactants for the named reactions mentioned in **List-I**. Match each entry in **List-I** with the appropriate entry in **List-II** and choose the correct option.

	List - I		List - II
(P)	Stephen reaction	(1)	Toluene $\xrightarrow[\text{(ii) } H_3O^+]{\text{(i) } CrO_2Cl_2/CS_2}$
(Q)	Sandmeyer reaction	(2)	Benzoic acid $\xrightarrow[\text{(iii) } P_4O_{10}, \Delta]{\text{(i) } PCl_5, \text{(ii) } NH_3}$
(R)	Hoffmann bromamide degradation reaction	(3)	Nitrobenzene $\xrightarrow[\text{(ii) } HCl, NaNO_2 (273-278\,K), H_2O]{\text{(i) } Fe, HCl}$
(S)	Cannizzaro reaction	(4)	Toluene $\xrightarrow[\text{(iii) } SO_2Cl_2, \text{(iv) } NH_3]{\text{(i) } Cl_2/h\nu, H_2O, \text{(ii) Tollen's reagent}}$
		(5)	Aniline $\xrightarrow[\text{(ii) } HNO_3, H_2SO_4, 288K, \text{(iii) aq. NaOH}]{\text{(i) } (CH_3CO)_2O, \text{Pyridine}}$

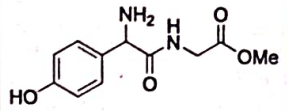
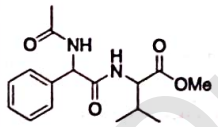
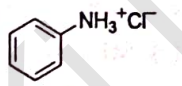
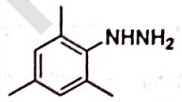
(*a*) (P) → (2); (Q) → (4); (R) → (1); (S) → (3)

(*b*) (P) → (2); (Q) → (3); (R) → (4); (S) → (1)

(*c*) (P) → (5); (Q) → (3); (R) → (4); (S) → (2)

(*d*) (P) → (5); (Q) → (4); (R) → (2); (S) → (1)

16. **Match the compounds in List-I with the appropriate observations in List-II and choose the correct option.**

	List - I		List - II
(P)		(1)	Reaction with phenyl diazonium salt gives yellow dye.
(Q)		(2)	Reaction with ninhydrin gives purple color and it also reacts with $FeCl_3$ to give violet color.
(R)		(3)	Reaction with glucose will give corresponding hydrazone.
(S)		(4)	Lassiagne extract of the compound treated with dilute HCl followed by addition of aqueous $FeCl_3$ gives blood red color.
		(5)	After complete hydrolysis, it will give ninhydrin test and it **DOES NOT** give positive phthalein dye test.

(*a*) (P) → (1); (Q) → (5); (R) → (4); (S) → (2)

(*b*) (P) → (2); (Q) → (5); (R) → (1); (S) → (3)

(*c*) (P) → (5); (Q) → (2); (R) → (1); (S) → (4)

(*d*) (P) → (2); (Q) → (1); (R) → (5); (S) → (3)

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Chemistry Paper-2

SECTION 1 (Maximum Marks: 12)

- This section contains **FOUR (04)** questions.
- Each question has **FOUR** options (*a*), (*b*), (*c*) and (*d*). **ONLY ONE** of these four options is the correct answer.
- For each question, choose the option corresponding to the correct answer.
- Answer to each question will be evaluated **according to the following marking scheme:**

Full Marks : +3 If **ONLY** the correct option is chosen;
Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);
Negative Marks : –1 In all other cases.

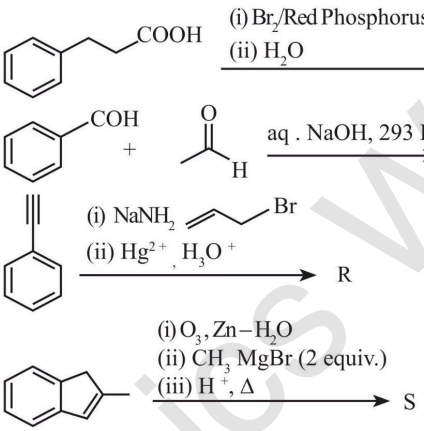
1. During sodium nitroprusside test of sulphide ion in an aqueous solution, one of the ligands coordinated to the metal ion is converted to

(*a*) NOS^- (*b*) SCN^- (*c*) SNO^- (*d*) NCS^-

2. The complete hydrolysis of ICl, ClF_3 and BrF_5, respectively, gives

(*a*) IO^-, ClO_2^- and BrO_3^- (*b*) IO_3^-, ClO_2^- and BrO_3^-
(*c*) IO^-, ClO^- and BrO_2^- (*d*) IO_3^-, ClO_4^- and BrO_2^-

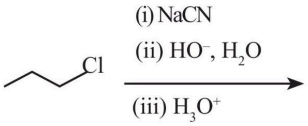
3. Monocyclic compounds P, Q, R and S are the major products formed in the reaction sequences given below.

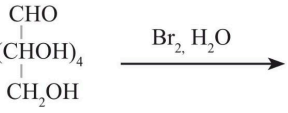


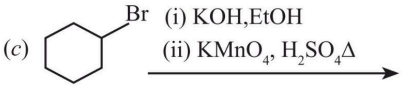
The product having the highest number of unsaturated carbon atom(s) is

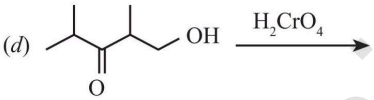
(*a*) P (*b*) Q (*c*) R (*d*) S

4. The correct reaction/reaction sequence that would produce a dicarboxylic acid as the major product is

(*a*) 

(*b*) 

(*c*) 

(*d*) 

SECTION 2 (Maximum Marks: 16)

- This section contains **FOUR (04)** questions.
- Each question has **FOUR** options (*a*), (*b*), (*c*) and (*d*). **ONE OR MORE THAN ONE** of these four option(s) is(are) correct answer(s).
- For each question, choose the option(s) corresponding to (all) the correct answer(s).
- Answer to each question will be evaluated **according to the following marking scheme:**

Full Marks : +4 **ONLY** if (all) the correct option(s) is(are) chosen;
Partial Marks : +3 If all the four options are correct but ONLY three options are chosen;
Partial Marks : +2 If three or more options are correct but ONLY two options are chosen, both of which are correct;
Partial Marks : +1 If two or more options are correct but ONLY one option is chosen and it is a correct option;
Zero Marks : 0 If none of the options is chosen (i.e. the question is unanswered);
Negative Marks : –2 In all other cases.

- For example, in a question, if (*a*), (*b*) and (*d*) are the ONLY three options corresponding to correct answers, then

choosing ONLY (*a*), (*b*) and (*d*) will get +4 marks;
choosing ONLY (*a*) and (*b*) will get +2 marks;
choosing ONLY (*a*) and (*d*) will get +2 marks;
choosing ONLY (*b*) and (*d*) will get +2 marks;
choosing ONLY (*a*) will get +1 mark;
choosing ONLY (*b*) will get +1 mark;
choosing ONLY (*d*) will get +1 mark;
choosing no option (i.e. the question is unanswered) will get 0 marks;
and choosing any other combination of options will get –2 marks.

5. The correct statement(s) about intermolecular forces is(are)

(*a*) The potential energy between two point charges approaches zero more rapidly than the potential energy between a point dipole and a point charge as the distance between them approaches infinity.

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(*b*) The average potential energy of two rotating polar molecules that are separated by a distance r has $1/r^3$ dependence.

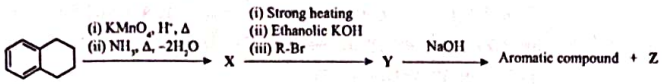
(*c*) The dipole-induced dipole average interaction energy is independent of temperature.

(*d*) Nonpolar molecules attract one another even though neither has a permanent dipole moment.

6. The compound(s) with P–H bond(s) is(are)

(*a*) H_3PO_4 (*b*) H_3PO_3 (*c*) $H_4P_2O_7$ (*d*) H_3PO_2

7. F or the reaction sequence given below, the correct statement(s) is(are)



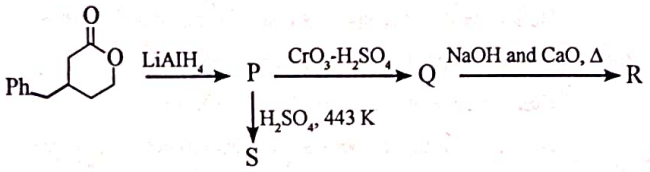
(*a*) Both X and Y are oxygen containing compounds.

(*b*) Y on heating with $CHCl_3$/KOH forms isocyanide.

(*c*) Z reacts with Hinsberg's reagent.

(*d*) Z is an aromatic primary amine.

8. F or the reaction sequence given below, the correct statement(s) is(are)



(*a*) P is optically active.

(*b*) S gives Bayer's test.

(*c*) Q gives effervescence with aq. $NaHCO_3$.

(*d*) R is an alkyne.

SECTION 3 (Maximum Marks: 32)

- This section contains **EIGHT (08)** questions.
- The answer to each question is a **NUMERICAL VALUE.**
- For each question, enter the correct numerical value of the answer using the mouse and the onscreen virtual numeric keypad in the place designated to enter the answer.
- If the numerical value has more than two decimal places, **truncate/round-off** the value to **TWO** decimal places.
- Answer to each question will be evaluated **according to the following marking scheme**:
  Full Marks : +4 If ONLY the correct numerical value is entered in the designated place;
  Zero Marks : 0 In all other cases.

9. The density (in g cm^{-3}) of the metal which forms a cubic close packed (ccp) lattice with an axial distance (edge length) equal to 400 pm is _____.

Use: Atomic mass of metal = 105.6 amu and Avogadro's constant = 6×10^{23} mol^{-1}

10. The solubility of barium iodate in an aqueous solution prepared by mixing 200 mL of 0.010 M barium nitrate with 100 mL of 0.10 M sodium iodate is $X \times 10^{-6}$ mol dm^{-3}. The value of X is _____.

Use: Solubility product constant (K_{sp}) of barium iodate = 1.58×10^{-9}

11. Adsorption of phenol from its aqueous solution on to fly ash obeys Freundlich isotherm. At a given temperature, from 10 mg g^{-1} and 16 mg g^{-1} aqueous phenol solutions, the concentrations of adsorbed phenol are measured to be 4 mg g^{-1} and 10 mg g^{-1}, respectively. At this temperature, the concentration (in mg g^{-1}) of adsorbed phenol from 20 mg g^{-1} aqueous solution of phenol will be _____.

Use: $\log_{10} 2 = 0.3$

12. Consider a reaction $A + R \rightarrow Product$. The rate of this reaction is measured to be $k[A][R]$. At the start of the reaction, the concentration of R, $[R]_0$, is 10-times the concentration of A, $[A]_0$. The reaction can be considered to be a pseudo first order reaction with assumption that $k[R] = k'$ is constant. Due to this assumption, the relative error (in %) in the rate when this reaction is 40 % complete, is _____.

[k and k' represent corresponding rate constants]

13. At 300 K, an ideal dilute solution of a macromolecule exerts osmotic pressure that is expressed in terms of the height (h) of the solution (density = 1.00 g cm^{-3}) where h is equal to 2.00 cm. If the concentration of the dilute solution of the macromolecule is 2.00 g dm^{-3}, the molar mass of the macromolecule is calculated to be $X \times 10^4$ g mol^{-1}. The value of X is _____.

Use: Universal gas constant (R) = 8.3 J K^{-1} mol^{-1} and acceleration due to gravity (g) = 10 m s^{-2}

14. An electrochemical cell is fueled by the combustion of butane at 1 bar and 298 K. Its cell potential is $\frac{X}{F} \times 10^3$ volts, where F is the Faraday constant. The value of X is _____.

Use: Standard Gibbs energies of formation at 298 K are: $\Delta_f G^o_{CO_2} = -394$ kJ mol^{-1}; $\Delta_f G^o_{water} = -237$ kJ mol^{-1}; $\Delta_f G^o_{butane} = -18$ kJ mol^{-1}

15. The sum of the spin only magnetic moment values (in B.M.) of $[Mn(Br)_6]^{-3}$ and $[Mn(CN)_6]^{3-}$ is _____.

16. A linear octasaccharide (molar mass = 1024 g mol^{-1}) on complete hydrolysis produces three monosaccharides: ribose, 2-deoxyribose and glucose. The amount of 2-deoxyribose formed is 58.26 % (w/w) of the total amount of the monosaccharides produced in the hydrolyzed products. The number of ribose unit(s) present in one molecule of octasaccharide is _____.

Use: Molar mass (in g mol^{-1}): ribose = 150, 2-deoxyribose = 134, glucose = 180; Atomic mass (in amu): H = 1, O = 16

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1 Some Basic Concepts of Chemistry

JEE-Main

Equilibrium in Physical and Chemical Processes

1. Choose the **correct** statements.

(A) Weight of a substance is the amount of matter present in it.

(B) Mass is the force exerted by gravity on an object.

(C) Volume is the amount of space occupied by a substance.

(D) Temperatures below 0°C are possible in Celsius scale, but in Kelvin scale negative temperature is not possible.

(E) Precision refers to the closeness of various measurements for the same quantity.

Choose the **correct** answer from the options given below:

[29 Jan, 2025 (Shift-I)]

(*a*) (B), (C) and (D) Only (*b*) (C), (D) and (E) Only

(*c*) (A), (B) and (C) Only (*d*) (A), (D) and (E) Only

2. The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 'A' × 10^{12} hertz and that has a radiant intensity in that direction of $\frac{1}{\text{'B'}}$ watt per steradian. 'A' and 'B' are respectively.

[09 April, 2024 (Shift-II)]

(*a*) 540 and $\frac{1}{683}$ (*b*) 540 and 683

(*c*) 450 and $\frac{1}{683}$ (*d*) 450 and 683

Uncertainty in Measurement and Laws of Chemical Combinations

3. Which of the following have same number of significant figures?

[8 April, 2023 (Shift-II)]

(A) 0.00253 (B) 1.0003

(C) 15.0 (D) 163

Choose the correct answer from the options given below

(*a*) A, B and C only (*b*) C and D only

(*c*) A, C and D only (*d*) B and C only

4. Using the rules for significant figures, the correct answer for the expression $\frac{0.02858 \times 0.112}{0.5702}$ **[29 June, 2022 (Shift-II)]**

(*a*) 0.005613 (*b*) 0.00561

(*c*) 0.0056 (*d*) 0.006

5. The number of significant figure in 0.00340 is _____.

[25 July, 2021 (Shift-II)]

6. The number of significant figures in 50000.020 × 10^{-3} is_____.

[26 Feb, 2021 (Shift-I)]

Dalton's Atomic Theory

7. Choose the Incorrect Statement about Dalton's Atomic Theory

[04 April, 2024 (Shift-II)]

(*a*) Compounds are formed when atoms of different elements combine in any ratio

(*b*) All the atoms of a given element have identical properties including identical mass

(*c*) Matter consists of indivisible atoms

(*d*) Chemical reactions involve recorganization of atoms

8. The incorrect postulates of the Dalton's atomic theory are:

(A) Atoms of different elements differ in mass.

(B) Matter consists of divisible atoms.

(C) Compounds are formed when atoms of different element combine in a fixed ratio.

(D) All the atoms of given element have different properties including mass.

(E) Chemical reactions involve reorganisation of atoms.

Choose the correct answer from the options given below:

[05 April, 2024 (Shift-I)]

(*a*) (B), (D), (E) only (*b*) (A), (B), (D) only

(*c*) (C), (D), (E) only (*d*) (B), (D) only

Atomic & Molecular Masses

9. The average molar mass of chlorine is 35.5 g mol^{-1}. The ratio of ^{35}Cl to ^{37}Cl in naturally occurring chlorine is close to:

[6 Sept, 2020 (Shift-II)]

(*a*) 4 : 1 (*b*) 3 : 1 (*c*) 2 : 1 (*d*) 1 : 1

Mole Concept and Molar Masses

10. 20 mL of sodium iodide solution gave 4.74 g silver iodide when treated with excess of silver nitrate solution. The molarity of the sodium iodide solution is _____ M. (Nearest Integer value)

(Given : $Na = 23, I = 127, Ag = 108, N = 14, O = 16$ g mol^{-1})

[08 April, 2025 (Shift-II)]

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11. The amount of calcium oxide produced on heating 150 kg limestone (75% pure) is_____kg. (Nearest integer)

Given : Molar mass (in g mol^{-1}) of Ca-40, O-16, C-12

[04 April, 2025 (Shift-II)]

12. Mass of magnesium required to produce 220 mL of hydrogen gas at STP on reaction with excess of dil. HCl is

Given : Molar mass of Mg is 24 g mol^{-1}.

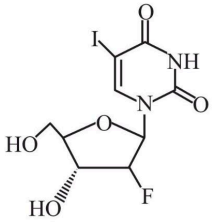
[03 April, 2025 (Shift-II)]

(*a*) 235.7 g (*b*) 0.24 mg (*c*) 236 mg (*d*) 2.444 g

13. Among 10^{-9} g (each) of the following elements, which one will have the highest number of atoms?
Element : Pb, Po, Pr and Pt **[03 April, 2025 (Shift-I)]**

(*a*) Po (*b*) Pr (*c*) Pb (*d*) Pt

14. 0.1 mol of the following given antiviral compound (P) will weigh _____ $\times 10^{-1}$ g **[02 April, 2025 (Shift-I)]**



(P)

(Given: molar mass in g mol^{-1} H: 1, C : 12, N : 14, O : 16, F : 19, I : 127)

15. On complete combustion 1.0 g of an organic compound (X) gave 1.46 g of CO_2 and 0.567 g of H_2O. The empirical formula mass of compound (X) is _____ g.
(Given molar mass in g mol^{-1} C : 12, H : 1, O : 16)

[02 April, 2025 (Shift-I)]

(*a*) 30 (*b*) 45 (*c*) 60 (*d*) 15

16. 0.01 mole of an organic compound (X) containing 10% hydrogen, on complete combustion produced 0.9 g H_2O. Molar mass of (X) is _____ g mol^{-1}. **[23 Jan, 2025 (Shift-II)]**

17. 2.8×10^{-3} mol of CO_2 is left after removing 10^{21} molecules from its '*x*' mg sample. The mass of CO_2 taken initially is
Given: $N_A = 6.02 \times 10^{23}$ mol^{-1} **[23 Jan, 2025 (Shift-I)]**

(*a*) 48.2 mg (*b*) 98.3 mg
(*c*) 150.4 mg (*d*) 196.2 mg

18. 0.05 cm thick coating of silver is deposited on a plate of 0.05 m^2 area. The number of silver atoms deposited on plate are _____ $\times 10^{23}$. (At mass Ag = 108, d = 7.9 g cm^{-3})

[30 Jan, 2024 (Shift-I)]

19. The number of molecules and moles in 2.8375 litres of O_2 at STP are respectively **[10 April, 2023 (Shift-I)]**

(*a*) 7.527×10^{22} and 0.250 mol (*b*) 1.505×10^{23} and 0.250 mol
(*c*) 7.527×10^{23} and 0.125 mol (*d*) 7.527×10^{22} and 0.125 mol

20. Match List-I with List-II. **[10 April, 2023 (Shift-II)]**

LIST-I		LIST-II	
A.	16g of $CH_4(g)$	I.	Weighs 28 g
B.	1g of $H_2(g)$	II.	60.2×10^{23} electrons
C.	1 mole of $N_2(g)$	III.	Weighs 32g
D.	0.5 mol of $SO_2(g)$	IV.	Occupies 11.4 L volume at STP

Choose the correct answer from the options given below:

(*a*) (A)-(I), B-(III), C-(II), D-(IV)
(*b*) (A)-(II), B-(III), C-(IV), D-(I)
(*c*) (A)-(II), B-(IV), C-(III), D-(I)
(*d*) (A)-(II), B-(IV), C-(I), D-(III)

21. When 0.01 mol of an organic compound containing 60% carbon was burnt completely, 4.4 g of CO_2 was produced. The molar mass of compound is _____ g mol^{-1} (Nearest integer)

[29 Jan, 2023 (Shift-II)]

22. Production of iron in blast furnace follows the following equation
$Fe_3O_4(s) + 4CO(g) \longrightarrow 3Fe(l) + 4CO_2(g)$
When 4.640 kg of Fe_3O_4 and 2.520 kg of CO are allowed to react then the amount of iron (in g) produced is:
[Given: Molar Atomic mass (g mol^{-1}); Fe = 56
Molar Atomic mass (g mol^{-1}); O = 16
Molar Atomic mass (g mol^{-1}); C = 12] **[29 June, 2022 (Shift-I)]**

(*a*) 1400 (*b*) 2200 (*c*) 3360 (*d*) 4200

23. SO_2Cl_2 on reaction with excess of water results into acidic mixture

$$SO_2Cl_2 + 2H_2O \rightarrow H_2SO_4 + 2HCl$$

16 moles of NaOH is required for the complete neutralisation of the resultant acidic mixture. The number of moles of SO_2Cl_2 used is:

[25 July, 2022 (Shift-I)]

(*a*) 16 (*b*) 8 (*c*) 4 (*d*) 2

24. Hemoglobin contains 0.34% of iron by mass. The number of Fe atoms in 3.3 g of hemoglobin is (Given: Atomic mass of Fe is 56 u, $N_A = 6.022 \times 10^{23}$ mol^{-1}.) **[26 July, 2022 (Shift-II)]**

(*a*) 1.21×10^5 (*b*) 12.0×10^{16} (*c*) 1.21×10^{20} (*d*) 3.4×10^{22}

25. 250 g solution of D-glucose in water contains 10.8% of carbon by weight. The molality of the solution is nearest to
(Given: Atomic weights are, H = 1u ; C = 12u ; O = 16u)

[27 July, 2022 (Shift-I)]

(*a*) 1.03 (*b*) 2.06 (*c*) 3.09 (*d*) 5.40

26. The number of N atoms in 681 g of $C_7H_5N_3O_6$ is $x \times 10^{21}$. The value of x is_____.
($N_A = 6.02 \times 10^{23}$ mol^{-1}) (Nearest Integer)

[25 June, 2022 (Shift-I)]

27. A protein 'A' contains 0.30% of glycine (molecular weight 75). The minimum molar mass of the protein 'A' is _____ $\times 10^3$ g mol^{-1} [nearest integer] **[25 June, 2022 (Shift-II)]**

28. CNG is an important transportation fuel. When 100 g CNG is mixed with 208 g oxygen in vehicles, it leads to the formation of CO_2 and H_2O and produces large quantity of heat during this combustion, then the amount of carbon dioxide produced in grams is_____. (nearest integer)
[Assume CNG to be methane] **[26 June, 2022 (Shift-II)]**

29. 56.0 L of nitrogen gas is mixed with excess of hydrogen gas and it is found that 20 L of ammonia gas is produced. The volume of unused nitrogen gas is found to be___ L. **[25 July, 2022 (Shift-II)]**

30. Chlorophyll extracted from the crushed green leaves was dissolved in water to make 2 L solution of Mg of concentration 48 ppm. The number of atoms of Mg in this solution is $x \times 10^{20}$ atoms. The value of x is _____. (Nearest Integer)
(Given: Atomic mass of Mg is 24 g mol^{-1}; $N_A = 6.02 \times 10^{23}$ mol^{-1})

[26 July, 2022 (Shift-I)]

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31. 1 L aqueous solution of H_2SO_4 contains 0.02 m mol H_2SO_4. 50% of this solution is diluted with deionized water to give 1 L solution (A). In solution (A), 0.01 m mol of H_2SO_4 are added. Total m mols of H_2SO_4 in the final solution is _____ $\times 10^3$ m moles.

[25 June, 2022 (Shift-I)]

32. Two elements A and B forms 0.15 moles of A_2B and AB_3 type compounds. If both A_2B and AB_3 weigh equally, then the atomic weight of A is_____ times of atomic weight of B.

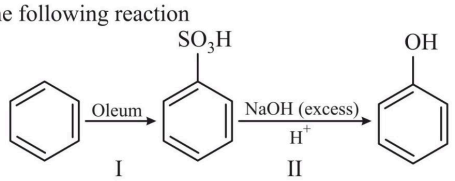
[27 June, 2022 (Shift-I)]

33. Number of grams of bromine that will completely react with 5.0 g of pent-1-ene is _____ $\times 10^{-2}$ g. (Atomic mass of Br = 80 g/mol) (Nearest Integer) **[25 June, 2022 (Shift-I)]**

34. The moles of methane required to produce 81 g of water after complete combustion is_____ $\times 10^{-2}$ mol. (nearest integer)

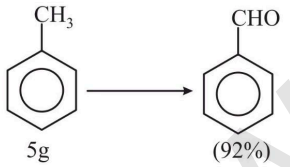
[26 June, 2022 (Shift-II)]

35. In the following reaction



The % yield for reaction I is 60% and that of reaction II is 50%. The overall yield of the complete reaction is_____% [Nearest integer] **[27 July, 2022 (Shift-I)]**

36. In the below reaction, 5g of toluene is converted into benzaldehyde with 92% yield. The amount of benzaldehyde produced is_____ $\times 10^{-2}$ g. (Nearest integer) **[27 July, 2022 (Shift-II)]**



37. A reaction of 0.1 mole of Benzylamine with bromomethane gave 23g of Benzyl trimethyl ammonium bromide. The number of moles of bromomethane consumed in this reaction are $n \times 10^{-1}$, when n = ____ (Round off to the nearest integer) [Given: Atomic masses: C: 12.0 u, H : 1.0u, N : 14.0u, Br : 80.0u] **[18 March, 2021 (Shift-I)]**

38. 4g equimolar mixture of NaOH and Na_2CO_3 contains x g of NaOH and y g of Na_2CO_3. The value of x is _____ g. (Nearest Integer)

[20 July, 2021 (Shift-II)]

39. Consider the complete combustion of butane, the amount of butane utilized to produce 72.0 g of water is_____ $\times 10^{-1}$g, (in nearest integer) **[25 July, 2021 (Shift-I)]**

40. The number of atoms in 8 g of sodium is $x \times 10^{23}$. The value of x is _____. (Nearest integer)

[Given: $N_A = 6.02 \times 10^{23}$ mol^{-1}, Atomic mass of Na = 23.0 u]

[1 Sept, 2021 (Shift-I)]

41. The $NaNO_3$ weighed out to make 50 mL of an aqueous solution containing 70.0 mg Na^+ per mL is____g. (Rounded off to the nearest integer) **[26 Feb, 2021 (Shift-II)]**

[Given; Atomic weight in g mol^{-1} –Na : 23; N :14; O :16]

42. The minimum number of moles of O_2 required for complete combustion of 1 mole of propane and 2 moles of butane is _____.

[5 Sept, 2020 (Shift-I)]

43. The mass of ammonia in grams produced when 2.8 kg of dinitrogen quantitatively reacts with 1 kg of dihydrogen is _____.

[4 Sept, 2020 (Shift-I)]

44. Ferrous sulphate heptahydrate is used to fortify foods with iron. The amount (in grams) of the salt required to achieve 10 ppm of iron in 100 kg of wheat is _____

Atomic weight: Fe = 55.85; S = 32.00; O = 16.00

[8 Jan, 2020 (Shift-I)]

45. $NaClO_3$ is used, even in spacecraft, to produce O_2. The daily consumption of pure O_2 by a person is 492L at 1 atm, 300 K. How much amount of $NaClO_3$, in grams, is required to produce O_2 for the daily consumption of a person at 1 atm, 300 K?

$NaClO_3(s) + Fe(s) \rightarrow O_2(g) + NaCl(s) + FeO(s)$

R = 0.082 L atm mol^{-1} K^{-1}. **[8 Jan, 2020 (Shift-II)]**

46. At 300 K and 1 atmospheric pressure, 10 mL of a hydrocarbon required 55 mL of O_2 for complete combustion and 40 mL of CO_2 is formed. The formula of the hydrocarbon is:

[10 April, 2019 (Shift-I)]

(*a*) C_4H_8 (*b*) C_4H_7Cl (*c*) C_4H_{10} (*d*) C_4H_6

47. 5 moles of AB_2 weigh 125×10^{-3} kg and 10 moles of A_2B_2 weigh 300×10^{-3} kg. The molar mass of $A_{(M_A)}$ and molar mass of $B_{(M_B)}$ in kg mol^{-1} are: **[12 April, 2019 (Shift-I)]**

(*a*) $M_A = 50 \times 10^{-3}$ and $M_B = 25 \times 10^{-3}$

(*b*) $M_A = 25 \times 10^{-3}$ and $M_B = 50 \times 10^{-3}$

(*c*) $M_A = 5 \times 10^{-3}$ and $M_B = 10 \times 10^{-3}$

(*d*) $M_A = 10 \times 10^{-3}$ and $M_B = 5 \times 10^{-3}$

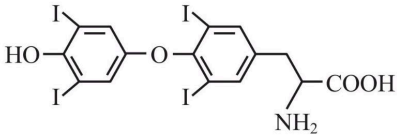
Percentage Composition and Empirical & Molecular Formula

48. On combustion 0.210 g of an organic compound containing C, H and O gave 0.127 g H_2O and 0.307 gCO_2. The percentages of hydrogen and oxygen in the given organic compound respectively are: **[08 April, 2025 (Shift-II)]**

(*a*) 53.41, 39.6 (*b*) 6.72, 53.41

(*c*) 7.55, 43.85 (*d*) 6.72, 39.87

49. Thyroxine, the hormone has given below structure.



The percentage of iodine in thyroxine is.....%. (nearest integer)

(Given molar mass in g mol^{-1} C:12, H:1, O:16, N:14, I:127)

[07 April, 2025 (Shift-I)]

50. An organic compound weighing 500 mg , produced 220 mg of CO_2, on complete combustion. The percentage composition of carbon in the compound is.....%. (nearest integer)

(Given molar mass in g mol^{-1} of C : 12, O : 16)

[07 April, 2025 (Shift-I)]

51. The elemental composition of a compound is 54.2% C, 9.2% H and 36.6% O.

If the molar mass of the compound is 132 g mol^{-1}, the molecular formula of the compound is :

[Given : The relative atomic mass of C : H : O = 12 : 1 : 16]

[24 Jan, 2025 (Shift-II)]

(*a*) $C_6H_{12}O_3$ (*b*) $C_4H_8O_2$ (*c*) $C_4H_9O_3$ (*d*) $C_6H_{12}O_6$

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52. Quantitative analysis of an organic compound (X) shows following % composition.

C: 14.5% Cl: 64.46%

H: 1.8%

Empirical formula mass of the compound (X) is _____ $\times 10^{-1}$

(Given molar mass in g mol $^{-1}$ of C:12, H:1, O:16, Cl:35.5)

[28 Jan, 2025 (Shift-I)]

53. A sample of $CaCO_3$ and $MgCO_3$ weighed 2.21 g is ignited to constant weight of 1.152 g. The composition of mixture is:

(Given molar mass in g mol^{-1} $CaCO_3$: 100, $MgCO_3$: 84)

[31 Jan, 2024 (Shift-II)]

(*a*) 1.187 g $CaCO_3$ + 1.023 g $MgCO_3$

(*b*) 1.023 g $CaCO_3$ + 1.023 g $MgCO_3$

(*c*) 1.187 g $CaCO_3$ + 1.187 g $MgCO_3$

(*d*) 1.023 g $CaCO_3$ + 1.187 g $MgCO_3$

54. 10 mL of gaseous hydrocarbon on combustion gives 40 mL of CO_2(g) and 50 mL of water vapour. Total number of carbon and hydrogen atoms in the hydrocarbon is _____.

[01 Feb, 2024 (Shift-II)]

55. An organic compound has 42.1% carbon, 6.4% hydrogen and remainder is oxygen. If its molecular weight is 342, then its molecular formula is: **[05 April, 2024 (Shift-I)]**

(*a*) $C_{11}H_{18}O_{12}$ (*b*) $C_{12}H_{20}O_{12}$ (*c*) $C_{14}H_{20}O_{10}$ (*d*) $C_{12}H_{22}O_{11}$

56. A metal chloride contains 55.0% of chlorine by weight. 100 mL vapours of the metal chloride at STP weigh 0.57 g. The molecular formula of the metal chloride is

(Given: Atomic mass of chlorine is 35.5 u)

[12 April, 2023 (Shift-I)]

(*a*) MCl_2 (*b*) MCl_4 (*c*) MCl_3 (*d*) MCl

57. An organic compound gives 0.220 g of CO_2 and 0.126 g of H_2O on complete combustion. If the % of carbon is 24, then the % hydrogen is _____ $\times 10^{-1}$. (Nearest integer) **[13 April, 2023 (Shift-I)]**

58. 0.5 g of an organic compound (X) with 60% carbon will produce _____ $\times 10^{-1}$ g of CO_2 on complete combustion.

[8 April, 2023 (Shift-I)]

59. 120 g of an organic compound that contains only carbon and hydrogen gives 330 g of CO_2 and 270 g of water on complete combustion. The percentage of carbon and hydrogen, respectively are **[24 June, 2022 (Shift-I)]**

(*a*) 25 and 75 (*b*) 40 and 60 (*c*) 60 and 40 (*d*) 75 and 25

60. Compound A contains 8.7% Hydrogen, 74% Carbon and 17.3% Nitrogen. The molecular formula of the compound is,

Given: Atomic masses of C, H and N are 12, 1 and 14 amu respectively. The molar mass of the compound A is 162 g mol^{-1}.

[28 June, 2022 (Shift-II)]

(*a*) $C_4H_6N_2$ (*b*) C_2H_3N (*c*) C_5H_7N (*d*) $C_{10}H_{14}N_2$

61. 116 g of a substance upon dissociation reaction yields 7.5 g of hydrogen, 60g of oxygen and 48.5 g of carbon. Given that the atomic masses of H, O and C are 1,16 and 12 g/mol respectively. The data agrees with how many formulae of the following?

[27 June, 2022 (Shift-II)]

(*a*) CH_3COOH (*b*) HCHO

(*c*) CH_3OOCH_3 (*d*) CH_3CHO

62. A 2.0 g sample containing MnO_2 is treated with HCl liberating Cl_2. The Cl_2 gas is passed into a solution of KI and 60.0 mL of 0.1 M $Na_2S_2O_3$ is required to titrate the liberated iodine. The percentage of MnO_2 in the sample is____. (Nearest integer)

[Atomic masses (in u) Mn = 55; Cl = 35.5; O = 16, I = 127, Na = 23, K = 39, S = 32] **[28 June, 2022 (Shift-I)]**

63. On complete combustion 0.30 g of an organic compound gave 0.20 g of carbon dioxide and 0.10 g of water. The percentage of carbon in the given organic compound is _____. (Nearest integer)

[26 June, 2022 (Shift-I)]

64. The complete combustion of 0.492 g of an organic compound containing 'C', 'H' and 'O' gives 0.793g of CO_2 and 0.442 g H_2O. The percentage of oxygen composition in the organic compound is _____. (nearest integer) **[28 June, 2022 (Shift-II)]**

65. In the estimation of bromine, 0.5 g of an organic compound gave 0.40 g of silver bromide. The percentage of bromine in the given compound is _____% (Nearest integer)

(Relative atomic masses of Ag and Br are 108 u and 80 u, respectively). **[28 June, 2022 (Shift-II)]**

66. Complete combustion of 1.80 g of an oxygen containing compound ($C_xH_yO_z$) gave 2.64 g of CO_2 and 1.08g of H_2O. The percentage of oxygen in the organic compound is **[25 Feb, 2021 (Shift-I)]**

(*a*) 53.33 (*b*) 50.33 (*c*) 63.53 (*d*) 51.63

67. Complete combustion of 750g of an organic compound provides 420 g of CO_2 and 210 g of H_2O. The percentage composition of carbon and hydrogen in organic compound is 15.3 and _____ respectively. (Round off to the nearest Integer).

[16 March, 2021 (Shift-I)]

68. Methylation of 10 g of benezene give 9.2 g of toluene. Calculate the percentage yield of toluene _____ . (Nearest integer)

[22 July, 2021 (Shift-II)]

69. The percentage composition of carbon by mole in methane is:

[8 April, 2019 (Shift-II)]

(*a*) 80% (*b*) 25% (*c*) 75% (*d*) 20%

70. A 10 mg effervescent tablet containing sodium bicarbonate and oxalic acid releases 0.25 ml of CO_2 at T = 298.15 K and p = 1 bar. If molar volume of CO_2 is 25.0 L under such condition, what is the percentage of sodium bicarbonate in each tablet?[Molar mass of $NaHCO_3$ = 84 g mol^{-1}] **[11 Jan, 2019 (Shift-I)]**

(*a*) 0.84 (*b*) 33.6 (*c*) 16.8 (*d*) 8.4

Stoichiometry & Stoichiometric Calculations

71. Butane reacts with oxygen to produce carbon dioxide and water following the equation given below.

$$C_4H_{10(g)} + \frac{13}{2}O_{2(g)} \rightarrow 4CO_{2(g)} + 5H_2O(l)$$

If 174.0 kg of butane is mixed with 320.0 kg of O_2, the volume of water formed in litres is ____.(Nearest integer)

[Given: (a) Molar mass of C, H, O are 12, 1, 16 g mol^{-1} respectively, (b) Density of water = 1 g mL^{-1}] **[07 April, 2025 (Shift-II)]**

72. $CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g)\ H_2O(l)$

Consider the above reaction, what mass of $CaCl_2$ will be formed if 250 mL of 0.76 M HCl reacts with 1000 g of $CaCO_3$?

(Given: Molar mass of Ca, C, O, H and Cl are 40, 12, 16, 1 and 35.5 g mol^{-1}, respectively) **[02 April, 2025 (Shift-I)]**

(*a*) 3.908 g (*b*) 2.636 g (*c*) 10.545 g (*d*) 5.272 g

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73. Some CO_2 gas was kept in a sealed container at a pressure of 1 atm and at 273 K. This entire amount of CO_2 gas was later passed through an aqueous solution of $Ca(OH)_2$. The excess unreacted $Ca(OH)_2$ was later neutralized with 0.1 M of 40 mL HCl. If the volume of the sealed container of CO_2 was x, then x is _____ cm^3 (nearest integer).
[**Given :** The entire amount of $CO_2(g)$ reacted with exactly half the initial amount of $Ca(OH)_2$ present in the aqueous solution.]
[22 Jan, 2025 (Shift-I)]

74. When 81.0 g of aluminium is allowed to react with 128.0 g of oxygen gas, the mass of aluminium oxide produced in grams is _____. (Nearest integer)
Molar mass of Al is 27.0 g mol^{-1}
Molar mass of O is 16.0 g mol^{-1} **[23 Jan, 2025 (Shift-II)]**

75. Consider the following reaction occurring in the blast furnace:
$$Fe_3O_{4(s)} + 4CO_{(g)} \rightarrow 3Fe_{(l)} + 4CO_2(g)$$
'x' kg of iron is produced when 2.32×10^3 kg Fe_3O_4 and 2.8×10^2 kg CO are brought together in the furnace. The value of 'x' is _____. (nearest integer)
{Given:
molar mass of Fe_3O_4 = 232 g mol^{-1}
molar mass of CO = 28 g mol^{-1}
molar mass of Fe = 56 g mol^{-1}} **[24 Jan, 2025 (Shift-I)]**

76. Mass of methane required to produce 22 g of CO_2 after complete combustion is _____ g.
(Given Molar mass in g mol^{-1}
C = 12.0
H = 1.0
O = 16.0) **[27 Jan, 2024 (Shift-I)]**

77. Number of moles of methane required to produce 22g $CO_{2(g)}$ after combustion is x × 10^{-2} moles. The value of x is
[31 Jan, 2024 (Shift-I)]

78. A compound (x) with molar mass 108 g mol^{-1} undergoes acetylation to give product with molar mass 192 g mol^{-1}. The number of amino groups in the compound (x) is ____. **[31 Jan, 2024 (Shift-II)]**

79. Consider the following reaction:
$$3PbCl_2 + 2(NH_4)_3PO_4 \rightarrow Pb_3(PO_4)_2 + 6NH_4Cl$$
If 72 mmol of $PbCl_2$ is mixed with 50 mmol of $(NH_4)_3PO_4$, then amount of $Pb_3(PO_4)_2$ formed is _____ mmol. (nearest integer)
[01 Feb, 2024 (Shift-I)]

80. Combustion of glucose ($C_6H_{12}O_6$) produces CO_2 and water. The amount of oxygen (in g) required for the complete combustion of 900 g of glucose is: [Molar mass of glucose in $gmol^{-1}$) = 180
[08 April, 2024 (Shift-I)]
(*a*) 480 (*b*) 960 (*c*) 800 (*d*) 32

81. If 279 g of aniline is reacted with one equivalent of benzenediazonium chloride, the maximum amount of aniline yellow formed will be _____ g (nearest integer).
(consider complete conversion) **[08 April, 2024 (Shift-I)]**

82. 9.3 g of pure aniline upon diazotisation followed by coupling with phenol gives an orange dye. The mass of orange dye produced (assume 100% yield/ conversion) is _____ g. (nearest integer)
[06 April, 2024 (Shift-I)]

83. The number of moles of methane required to produce 11g $CO_2(g)$ after complete combustion is:
(Given molar mass of methane in g mol^{-1} : 16)
[05 April, 2024 (Shift-II)]
(*a*) 0.75 (*b*) 0.25 (*c*) 0.35 (*d*) 0.5

84. X g of enthanamine was subjected to reaction with $NaNO_2$/HCl followed by hydrolysis to liberate N_2 and HCl. The HCl generated was completely neutralised by 0.2 moles of NaOH. X is ____ g.
[05 April, 2024 (Shift-II)]

85. In the Claisen-Schmidt reaction to prepare 351 g of dibenzalacetone using 87 g of acetone, the amount of benzaldehyde required is _____g. (Nearest integer)
[05 April, 2024 (Shift-II)]

86. 9.3 g of pure aniline is treated with bromine water at room temperature to give a white precipitate of the product 'P'. The mass of product 'P' obtained is 26.4 g. The percentage yield is ____%.
[05 April, 2024 (Shift-I)]

87. X g of ethylamine is subjected to reaction with $NaNO_2$/HCl followed by water; evolved dinitrogen gas which occupied 2.24 L volume at STP. X is _____ × 10^{-1} g. **[04 April, 2024 (Shift-I)]**

88. From 6.55 g of aniline, the maximum amount of acetanilide that can be prepared will be ___ ×10^{-1} g.
[04 April, 2024 (Shift-II)]

89. When a hydrocarbon A undergoes combustion in the presence of air, it requires 9.5 equivalents of oxygen and produces 3 equivalents of water. What is the molecular formula of A?
[29 Jan, 2023 (Shift-II)]
(*a*) C_8H_6 (*b*) C_9H_9 (*c*) C_6H_6 (*d*) C_9H_6

90. When a hydrocarbon A undergoes complete combustion it requires 11 equivalents of oxygen and produces 4 equivalents of water. What is the molecular formula of A? **[31 Jan, 2023 (Shift-II)]**
(*a*) C_9H_8 (*b*) $C_{11}H_4$ (*c*) C_5H_8 (*d*) $C_{11}H_8$

91. 1 g of a carbonate (M_2CO_3) on treatment with excess HCl produces 0.01 mol of CO_2. The molar mass of M_2CO_3 is ___ g mol^{-1}. (Nearest integer) **[13 April, 2023 (Shift-II)]**

92. On complete combustion, 0.492 g of an organic compound gave 0.792 g of CO_2. The % of carbon in the organic compound is _____ (Nearest integer) **[31 Jan, 2023 (Shift-I)]**

93. Number of hydrogen atoms per molecule of a hydrocarbon A having 85.8% carbon is _____
(Given: Molar mass of A = 84 g mol^{-1}) **[25 Jan, 2023 (Shift-II)]**

94. Zinc reacts with hydrochloric acid to give hydrogen and zinc chloride. The volume of hydrogen gas produced at STP from the reaction of 11.5 g of zinc with excess HCl is _____ L (Nearest integer)
(Given : Molar mass of Zn is 65.4g mol^{-1} and Molar volume of H_2 at STP = 22.7L) **[31 Jan, 2023 (Shift-I)]**

95. Assume carbon burns according to following equation:
$$2C_{(s)} + O_{2(g)} \rightarrow 2CO(g)$$
When 12 g carbon is burnt in 48 g of oxygen, the volume of carbon monoxide produced is _____× 10^{-1} L at STP [nearest integer]
[Given: Assume CO as ideal gas, Mass of C is 12 g mol^{-1}, Mass of O is 16 g $mol^{-1}$and molar volume of an ideal gas at STP is 22.7 L mol^{-1}] **[31 Jan, 2023 (Shift-II)]**

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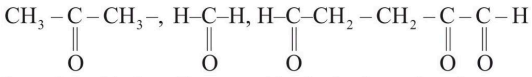
96. If 5 moles of $BaCl_2$ is mixed with 2 moles of Na_3PO_4, the maximum number of moles of $Ba_3(PO_4)_2$ formed is
(Nearest integer) **[6 April, 2023 (Shift-I)]**

97. The volume of hydrogen liberated at STP by treating 2.4 g of magnesium with excess of hydrochloric acid is _____ $\times 10^{-2}$ L.
Given: Molar volume of gas is 22.4 L at STP. Molar mass of magnesium is 24 g mol^{-1}. **[11 April, 2023 (Shift-II)]**

98. 17 mg of a hydrocarbon (M.F. $C_{10}H_{16}$) takes up 8.40 mL of the H_2 gas measured at 0ºC and 760 mm of Hg. Ozonolysis of the same hydrocarbon yields. **[29 Jan, 2023 (Shift-I)]**



The number of double bond/s present in the hydrocarbon is

99. If a rocket runs on a fuel ($C_{15}H_{30}$) and liquid oxygen, the weight of oxygen required and CO_2 released for every litre of fuel respectively are: **[24 June, 2022 (Shift-I)]**
(Given: density of the fuel is 0.756 g/mL)
(*a*) 1188 g and 1296 g (*b*) 2376 g and 2592 g
(*c*) 2592 g and 2376 g (*d*) 3429 g and 3142 g

100. Consider the reaction
$4HNO_3(l) + 3KCl(s) \rightarrow Cl_2(g) + NOCl(g) + 2H_2O(g) + 3KNO_3(s)$
The amount of HNO_3 required to produce 110.0 g of KNO_3 is
(Given: Atomic masses of H, O, N and K are 1, 16, 14 and 39, respectively) **[29 July, 2022 (Shift-II)]**
(*a*) 32.2g (*b*) 69.4g (*c*) 91.5g (*d*) 162.5g

101. $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
20g 5g
Consider the above reaction, the limiting reagent of the reaction and number of moles of NH_3 formed respectively are:
[29 July, 2022 (Shift-I)]
(*a*) H_2, 1.42 moles (*b*) H_2, 0.71 moles
(*c*) N_2, 1.42 moles (*d*) N_2, 0.71 moles

102. The normality of H_2SO_4 in the solution obtained on mixing 100 mL of 0.1 M H_2SO_4 with 50 mL of 0.1 M NaOH is _____ $\times 10^{-1}$ N. (Nearest Integer) **[27 July, 2022 (Shift-II)]**

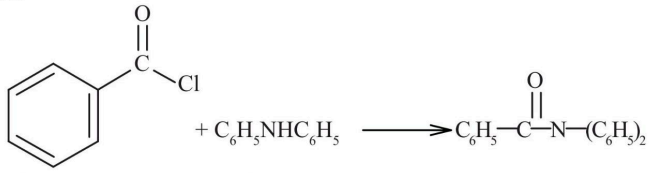
103. In the given reaction, $X + Y + 3Z \rightleftharpoons XYZ_3$
If one mole of each of X and Y with 0.05 mol of Z gives compound XYZ_3. (Given: Atomic masses of X, Y and Z are 10, 20 and 30 amu, respectively.) The yield of XYZ_3 is _____ g. (Nearest integer)
[28 July, 2022 (Shift-I)]

104. 2L of 0.2 M H_2SO_4 is reacted with 2L of 0.1 M NaOH solution, the molarity of the resulting product Na_2SO_4 in the solution is _____ millimolar (Nearest integer) **[28 July, 2022 (Shift-II)]**

105. When 200 mL of 0.2 M acetic acid is shaken with 0.6 g of wood charcoal, the final concentration of acetic acid after adsorption is 0.1M. The mass of acetic acid adsorbed per gram of carbon is ___ g.
[24 June, 2022 (Shift-II)]

106. A 0.166 g sample of an organic compound was digested with conc. H_2SO_4 and then distilled with NaOH. The ammonia gas evolved was passed through 50.0 mL of 0.5 N H_2SO_4. The used acid required 30.0 mL of 0.25 N NaOH for complete neutralization. The mass percentage of nitrogen in the organic compound is_____.
[24 June, 2022 (Shift-I)]

107.



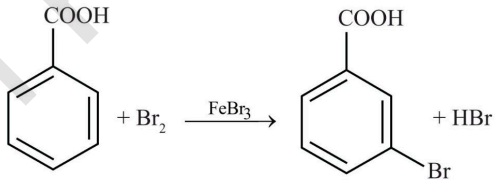
0.140g 0.388g 0.210g

Consider the above reaction. The percentage yield of amide product is _____.
(Round off to the nearest integer).
(Given: Atomic mass: C : 12.0u, H : 1.0 u, N : 14.0 u, O : 16.0 u, Cl : 35.5 u) **[17 March, 2021 (Shift-II)]**

108. The formula of a gaseous hydrocarbon which requires 6 times of its own volume of O_2 for complete oxidation and produces 4 times its own volume of CO_2 is C_xH_y. The value of y is _____.
[24 Feb, 2021 (Shift-II)]

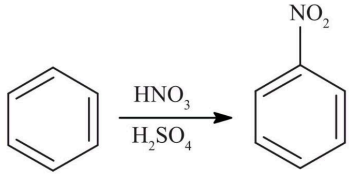
109. _____ grams of 3-Hydroxy propanal (MW=74) must be dehydrated to produce 7.8g of acrolein (MW = 56) (C_3H_4O) if the percentage yield is 64. (Round off to the nearest integer).
[18 March, 2021 (Shift-I)]
[Given: Atomic masses : C : 12.0u, H : 1.0u, O : 16.0u]

110.



Consider the above reaction where 6.1 g of Benzoic acid is used to get 7.8g of m- bromo benzoic acid. The percentage yield of the product is_____. (Round off to the nearest integer).
[Given: Atomic masses: C : 12.0u, H : 1.0u, O : 16.0u, Br : 80.0 u]
[18 March, 2021 (Shift-II)]

111.



In the above reaction, 3.9 g of benzene on nitration gives 4.92 g of nitrobenzene. The percentage yield of nitrobenzene in the above reaction is_____ %
(Round off to the nearest integer).
(Given atomic mass: C: 12.0u, H:1.0u, O:16.0u, N:14.0u)
[17 March, 2021 (Shift-I)]

112. Complete combustion of 3g of ethane gives x × 10^{22} molecules of water. The value of x is _____. (Round off to the nearest integer).
[Use : $N_A = 6.023 \times 10^{23}$; Atomic masses in u: C:12.0, O:16.0; H:1.0] **[17 March, 2021 (Shift-I)]**

113. 100 g of propane is completely reacted with 1000 g of oxygen. The mole fraction of carbon dioxide in the resulting mixture is x $\times 10^{-2}$. The value of x is _____. (Nearest integer)
[Atomic weight: H = 1.008; C = 12.00; O = 16.00]
[27August 2021 (Shift-II)]

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114. The first and second ionisation enthalpies of a metal are 496 and 4560 kJ mol^{-1}, respectively. How many moles of HCl and H_2SO_4, respectively, will be needed to react completely with 1 mole of the metal hydroxide?

[9 Jan, 2020 (Shift-II)]

(*a*) 1 and 1 (*b*) 1 and 2
(*c*) 2 and 0.5 (*d*) 1 and 0.5

115. 5 g of zinc is treated separately with an excess of
(A) dilute hydrochloric acid and
(B) aqueous sodium hydroxide.
The ratio of the volumes of H_2 evolved in these two reactions is:

[9 Jan, 2020 (Shift-II)]

(*a*) 1 : 4 (*b*) 1 : 1 (*c*) 1 : 2 (*d*) 2 : 1

116. The ammonia(NH_3) released on quantitative reaction of 0.6 g urea (NH_2CONH_2) with sodium hydroxide(NaOH) can be neutralized by **[7 Jan, 2020 (Shift-II)]**

(*a*) 100 mL of 0.1 N HCl (*b*) 100 mL of 0.2 N HCl
(*c*) 200 mL of 0.2 N HCl (*d*) 200 mL of 0.4 N HCl

117. A solution of phenol in chloroform when treated with aqueous NaOH gives compound P as a major product. The mass percentage of carbon in P is _____. (to the nearest integer) (Atomic mass: C = 12 ; H = 1 ; O = 16) **[6 September, 2020 (Shift-II)]**

118. For the following reaction, the mass of water produced from 445 g of $C_{57}H_{110}O_6$ is:
$2C_{57}H_{110}O_6\,(s) + 163\,O_2\,(g) \rightarrow 114\,CO_2\,(g) + 110\,H_2O\,(l)$

[9 Jan, 2019 (Shift-II)]

(*a*) 490 g (*b*) 445 g (*c*) 495 g (*d*) 890 g

119. 50 mL of 0.5 M oxalic acid is needed to neutralize 25 ml of sodium hydroxide solution. The amount of NaOH in 50 mL of the given sodium hydroxide solution is: **[12 Jan, 2019 (Shift-I)]**

(*a*) 40 g (*b*) 10 g (*c*) 20 g (*d*) 80 g

120. For a reaction,
$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$;
Identify dihydrogen (H_2) as a limiting reagent in the following reaction mixtures. **[9 April, 2019 (Shift-I)]**

(*a*) 14 g of N_2 + 4 g of H_2 (*b*) 28 g of N_2 + 6 g of H_2
(*c*) 56 g of N_2 + 10 g of H_2 (*d*) 35 g of N_2 + 8 g of H_2

JEE-Advanced

Mole Concept, Percentage Composition, Molar Masses, and Empirical Formula

Single Correct

1. An aqueous solution of 6.3 g oxalic acid dihydrate is made up to 250 mL. The volume of 0.1 N NaOH required to completely neutralise 10 mL of this solution is **(IIT JEE 2001)**

(*a*) 40 mL (*b*) 20 mL (*c*) 10 mL (*d*) 4 mL

2. The normality of 0.3M phosphorus acid (H_3PO_3) is **(IIT JEE 1999)**

(*a*) 0.1 (*b*) 0.9 (*c*) 0.3 (*d*) 0.6

3. In which mode of expression, the concentration of a solution remains independent of temperature? **(IIT JEE 1998)**

(*a*) Molarity (*b*) Normality
(*c*) Formality (*d*) Molality

4. The volume strength of 1.5 NH_2O_2 is **(IIT JEE 1990)**

(*a*) 4.8 (*b*) 8.4 (*c*) 3.0 (*d*) 8.0

5. A molal solution is one that contains one mole of solute in **(IIT JEE 1986)**

(*a*) 1000 g of solvent (*b*) 1.0 L of solvent
(*c*) 1.0 L of solution (*d*) 22.4 L of solution

6. If 0.50 mole of $BaCl_2$ is mixed with 0.20 mole of Na_3PO_4, the maximum number of moles of $Ba_3(PO_4)_2$ that can be formed is **(IIT JEE 1981)**

(*a*) 0.70 (*b*) 0.50 (*c*) 0.20 (*d*) 0.10

7. The total number of electrons in one molecule of carbon dioxide is **(IIT JEE 1979)**

(*a*) 22 (*b*) 44 (*c*) 68 (*d*) 88

Numerical/Integer Type

8. To form a complete monolayer of acetic acid on 1g of charcoal, 100 mL of 0.5M acetic acid was used. Some of the acetic acid remained unadsorbed. To neutralize the unadsorbed acetic acid, 40 mL of 1 M NaOH solution was required. If each molecule of acetic acid occupies $P \times 10^{-23}\,\mu^2$ surface area on charcoal, the value of P is _____.
[Use given data: Surface area of charcoal = $1.5 \times 10^2\ m^2g^{-1}$; Avogadro's number ($N_A$) = $6.0 \times 10^{23}\ mol^{-1}$]

C-15.73 W-60.25 UA-24.03 (JEE Adv. 2024)

9. Aluminium reacts with sulphuric acid to form aluminium sulphate and hydrogen. What is the volume of hydrogen gas in litre (L) produced at 300 K and 1.0 atm pressure, when 5.4 g of aluminium and 50.0 mL of 5.0 M sulphuric acid are combined for the reaction? (Use molar mass of aluminium as 27.0 g mol^{-1}, R = 0.082 atm L mol^{-1} K^{-1}) **C-18.21 W-64.19 UA-17.6 PC-0 (JEE Adv. 2020)**

10. The mole fraction of urea in an aqueous urea solution containing 900 g of water is 0.05. If the density of the solution is 1.2 g cm^{-3}, the molarity of urea solution is ___.
(Given data: Molar masses of urea and water are 60 g mol^{-1} and 18 g mol, respectively) **C-17.05 W-70.35 UA-12.61 (JEE Adv. 2019)**

11. The mole fraction of a solute in a solution is 0.1. At 298 K, molarity of this solution is the same as its molality. Density of this solution at 298 K is 2.0 g cm^{-3}. The ratio of the molecular weights of the solute and solvent, $\left(\frac{m_{solute}}{m_{solvent}}\right)$ is ...

C-28.66 W-66.23 UA-5.11 (JEE Adv. 2016)

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12. A compound H_2X with molar weight of 80 g is dissolved in a solvent having density of 0.4 g mL^{-1}. Assuming no change in volume upon dissolution, the molality of a 3.2 molar solution is
C-39.97 W-51.56 UA-8.47 (JEE Adv. 2014)

13. 29.2% (w/W) HCl stock solution has density of 1.25 g mL^{-1}. The molecular weight of HCl is 36.5 g mol^{-1}. The volume (mL) of stock solution required to prepare a 200 mL solution 0.4 M HCl is
C-15.53 W-67.67 UA-16.8 (IIT JEE 2012)

Fill in the Blanks

14. 3.0 g of a salt of molecular weight 30 is dissolved in 250 g water. The molality of the solution is ..... **(IIT JEE 1983)**

15. The total number of electrons present in 18 mL of water is .....
(IIT JEE 1980)

Subjective

16. 20% surface sites have adsorbed N_2. On heating N_2 gas evolved from sites and were collected at 0.001 atm and 298 K in a container of volume is 2.46 cm^3. Density of surface sites is $6.023 \times 10^{14}/cm^2$ and surface area is 1000 cm^2, find out the number of surface sites occupied per molecule of N_2. **(IIT JEE 2005)**

17. Calculate the amount of calcium oxide required when it reacts with 852 g of P_4O_{10}. **(IIT JEE 2005)**

18. In a solution of 100 mL 0.5 M acetic acid, one gram of active charcoal is added, which adsorbs acetic acid. It is found that the concentration of acetic acid becomes 0.49M. If surface area of charcoal is 3.01×10^2 m^2, calculate the area occupied by a single acetic acid molecule on the surface of charcoal. **(IIT JEE 2003)**

19. Find the molarity of water. Given: $\rho = 1000$ kg/m^3 **(IIT JEE 2003)**

20. How many millilitres of 0.5M H_2SO_4 are needed to dissolve 0.5 g of copper (II) carbonate? **(IIT JEE 1999)**

21. An aqueous solution containing 0.10 g KIO_3 (formula weight = 214.0) was treated with an excess of KI solution. The solution was acidified with HCl. The liberated I_2 consumed 45.0 mL of thiosulphate solution decolourise the blue starch-iodine complex. Calculate the molarity of the sodium thiosulphate solution. **(IIT JEE 1998)**

22. To a 25 mL H_2O_2 solution, excess of acidified solution of potassium iodide was added. The iodine liberated required 20 mL of 0.3 N sodium thiosulphate solution. Calculate the volume strength of H_2O_2 solution **(IIT JEE 1997)**

23. A 5.0 cm^3 solution of H_2O_2 liberates 0.508 g of iodine from an acidified KI solution. Calculate the strength of H_2O_2 solution in terms of volume strength at STP. **(IIT JEE 1995)**

24. 8.0575×10^{-2} kg of Glauber's salt is dissolved in water to obtain 1 dm^3 of solution of density 1077.2 kg m^{-3}. Calculate the molality, molarity and mole fraction of Na_2SO_4 in solution.**(IIT JEE 1994)**

25. Upon mixing 45.0 mL, 0.25 M lead nitrate solution with 25.0 mL of a 0.10 M chromic sulphate solution, precipitation of lead sulphate takes place. How many moles of lead sulphate are formed? Also calculate the molar concentrations of species left behind in the final solution. Assume that lead sulphate is completely insoluble.
(IIT JEE 1993)

26. Calculate the molality of 1.0 L solution of 93% H_2SO_4, (weight/volume). The density of the solution is 1.84 g/mL. **(IIT JEE 1990)**

27. n-butane is produced by monobromination of ethane followed by Wurtz's reaction. Calculate volume of ethane at NTP required to produce 55 g n-butane, if the bromination takes place with 90% yield and the Wurtz's reaction with 85% yield. **(IIT JEE 1989)**

28. A sugar syrup of weight 214.2 g contains 34.2 g of sugar ($C_{12}H_{22}O_{11}$). Calculate (i) molal concentration and (ii) mole fraction of sugar in syrup **(IIT JEE 1988)**

29. An unknown compound of carbon, hydrogen and oxygen contains 69.77%C and 11.63%H and has a molecular weight of 86. It does not reduce Fehling's solution but forms a bisulfite addition compound and gives a positive iodoform test. What is the possible structure(s) of unknown compounds? **(IIT JEE 1987)**

30. The density of a 3M sodium thiosulphate solution ($Na_2S_2O_3$) is 1.25 g per mL. Calculate (i) the percentage by weight of sodium thiosulphate (ii) the mole fraction of sodium thiosulphate and (iii) the molalities of Na^+ and $S_2O_3^{2-}$ ions. **(IIT JEE 1983)**

31. In the analysis of 0.5 g sample of feldspar, a mixture of chlorides of sodium and potassium is obtained, which weighs 0.1180 g. Subsequent treatment of the mixed chlorides with silver nitrate gives 0.2451 g of silver chloride. What is the percentage of sodium oxide and potassium oxide in the sample? **(IIT JEE 1979)**

32. The vapor density (hydrogen = 1) of a mixture consisting of NO_2 and N_2O_4 is 38.3 at 26.7°C. Calculate the number of moles of NO_2 in 100 g of the mixture. **(IIT JEE 1979)**

Uncertainty in Measurement and Laws of Chemical Combinations, Atomic and Molecular Masses, Stoichiometry and Stoichiometric Calculation

Single Correct

33. 2.76 g of silver carbonate on being strongly heated yields a residue weighing **(IIT JEE 1979)**
(*a*) 2.16 g (*b*) 2.48 g (*c*) 2.32 g (*d*) 2.64 g

34. When the same amount of zinc is treated separately with excess of sulphuric acid and excess of sodium hydroxide, the ratio of volumes of hydrogen evolved is **(IIT JEE 1979)**
(*a*) 1:1 (*b*) 1:2
(*c*) 2:1 (*d*) 9 : 4

35. The largest number of molecules is in **(IIT JEE 1979)**
(*a*) 36 g of water
(*b*) 28 g of CO
(*c*) 46 g of ethyl alcohol
(*d*) 54 g of nitrogen pentoxide (N_2O_5)

36. A gaseous mixture contains oxygen and nitrogen in the ratio of 1:4 by weight. Therefore, the ratio of their number of molecules is
(IIT JEE 1979)
(*a*) 1:4 (*b*) 1:8 (*c*) 7:32 (*d*) 88

Multiple Correct

37. To check the principle of multiple proportions, a series of pure binary compounds (P_mQ_n) were analyzed and their composition is tabulated below. The correct option(s) is(are)
C-14.77 W-26.73 UA-39.64 (JEE Adv. 2022)

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Compound	Weight % of P	Weight % of Q
1	50	50
2	44.4	55.6
3	40	60

(*a*) If empirical formula of compound 3 is P_3Q_4, then the empirical formula of compound 2 is P_3Q_5

(*b*) If empirical formula of compound 3 is P_3Q_2 and atomic weight of element P is 20, then the atomic weight of Q is 45.

(*c*) If empirical formula of compound 2 is PQ, then the empirical formula of the compound 1 is P_5Q_4.

(*d*) If atomic weight of P and Q are 70 and 35, respectively, then the empirical formula of compound 1 is P_2Q.

Numerical/Integer Type

38. The stoichiometric reaction of 516 g of dimethyldi-chlorosilane with water results in a tetrameric cyclic product X in 75% yield. The weight (in g) of X obtained is___.
[Use, molar mass (g mol^{-1}): H = 1, C = 12, O = 16, Si = 28, Cl = 35.5] **C-3.16 W-59.71 UA-37.13 (JEE Adv. 2023)**

39. Dissolving 1.24 g of white phosphorous in boiling NaOH solution in an inert atmosphere gives gas Q. The amount of $CuSO_4$ (in g) required to completely consume the gas Q is____.
[Given: Atomic mass of H = 1, 0 = 16, Na = 23, P = 31, S = 32, Cu = 63] **C1.78 W53.98 UA44.24 (JEE Adv. 2022)**

40. Galena (an ore) is partially oxidized by passing air through it at high temperature. After some time, the passage of air is stopped, but the heating is continued in a closed furnace such that the contents undergo self-reduction. The weight (in Kg) of Pb produced per kg of O_2 consumed is

(Atomic weights in g/mol :O = 16, S = 32, Pb = 207)

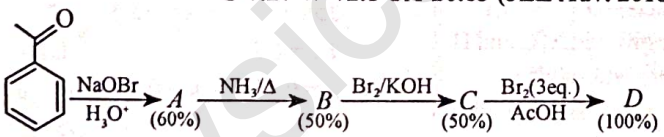
C-8.91 W-71.9 UA-19.2 (JEE Adv. 2018)

41. In the following reaction sequence, the amount of D (in gram) formed from 10 moles of acetophenone is .....

(Atomic weights in g mol^{-1} : H = 1, C = 12, N = 14,

O = 16, Br = 80. The yield (%) corresponding to the product in each step is given in the parenthesis)

C-7.27 W-72.1 UA-20.63 (JEE Adv. 2018)



42. A student performs a titration with different burettes and finds titrate values of 25.2 mL, 25.25 mL, and 25.0 mL. The number of significant figures in the average titrate value is **(IIT JEE 2010)**

Fill in the Blanks

43. The compound $YBa_2Cu_3O_7$, which shows super conductivity, has copper in oxidation state ..... Assume that the rare earth element yttrium is in its usual +3 oxidation state. **(IIT JEE 1994)**

44. The weight of 1×10^{22} molecules of $CuSO_4\cdot5H_2O$ is _____ **(IIT JEE 1991)**

45. The modern atomic mass unit is based on the mass of _____ **(IIT JEE 1980)**

Subjective

46. A plant virus is found to consist of uniform cylindrical particles of 150 in diameter and 5000 angstrom long. The specific volume of the virus is 0.75 cm^3/g. If the virus is considered to be a single particle, find its molar mass. **(IIT JEE 1999)**

47. A 3.00 g sample containing Fe_3O_4, Fe_2O_3 and an inert impure substance, is treated with excess of KI solution in presence of dilute H_2SO_4. The entire iron is converted into Fe^{2+} along with the liberation of iodine. The resulting solution is diluted to 100 mL. A 20 mL of the diluted solution requires 11.0 mL of 0.5M$Na_2S_2O_3$ solution to reduce the iodine present. A 50 mL of the dilute solution, after complete extraction of the iodine required 12.80 mL of 0.25M$KMnO_4$ solution in dilute H_2SO_4 medium for the oxidation of Fe^{2+}. Calculate the percentage of Fe_2O_3 and Fe_3O_4 in the original sample. **(IIT JEE 1996)**

48. A 20.0 cm^3 mixture of CO, CH_4 and He gases is exploded by an electric discharge at room temperature with excess of oxygen. The volume contraction is found to be 13.0 cm^3.

A further contraction of 14.0 cm^3 occurs when the residual gas is treated with KOH solution. Find out the composition of the gaseous mixture in terms of volume percentage. **(IIT JEE 1995)**

49. A is a binary compound of a univalent metal. 1.422 g of A reacts completely with 0.321 g of sulphur in an evacuated and sealed tube to give 1.743 g of a white crystalline solid B, that forms a hydrated double salt, C with $Al_2(SO_4)_3$. Identify A, B and C. **(IIT JEE 1994)**

50. One gram of commercial $AgNO_3$ is dissolved in 50 mL of water. It is treated with 50 mL of a KI solution. The silver iodide thus precipitated is filtered off. Excess of KI in the filtrate is titrated with (M/10) KIO_3 solution in presence of 6 M HCl till all I^- ions are converted into ICl. It requires 50 mL of (M/10) KIO_3 solution, 20 mL of the same stock solution of KI requires 30 mL of (M/10) KIO_3 under similar conditions. Calculate the percentage of $AgNO_3$ in the sample.

Reaction $KIO_3 + 2KI + 6HCl \rightarrow 3ICl + 3KCl + 3H_2O$ **(IIT JEE 1991)**

51. A solid mixture (5.0 g) consisting of lead nitrate and sodium nitrate was heated below 600°C until the weight of the residue was constant. If the loss in weight is 28.0 per cent, find the amount of lead nitrate and sodium nitrate in the mixture. **(IIT JEE 1990)**

52. 1.0 L of a mixture of CO and CO_2 is taken. This mixture is passed through a tube containing red hot charcoal. The volume now becomes 1.6 L. The volumes are measured under the same conditions. Find the composition of the mixture by volume. **(IIT JEE 1980)**

53. 5.00 mL of a gas containing only carbon and hydrogen were mixed with an excess of oxygen (30 mL) and the mixture exploded by means of electric spark. After explosion, the volume of the mixed gases remaining was 25 mL. On adding a concentrated solution of KOH, the volume further diminished to 15 mL, the residual gas being pure oxygen. All volumes have been reduced to NTP. Calculate the molecular formula of the hydrocarbon gas. **(IIT JEE 1979)**

54. Accounts for the following. Limit your answer to two sentences, "Atomic weights of most of the elements are fractional". **(IIT JEE 1979)**

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ANSWER KEY

JEE-MAIN

1. (*b*)	2. (*b*)	3. (*c*)	4. (*b*)	5. [3]	6. [8]	7. (*a*)	8. (*d*)	9. (*b*)	10. [1]
11. [63]	12. (*c*)	13. (*b*)	14. [372]	15. (*a*)	16. [100]	17. (*d*)	18. [11]	19. (*d*)	20. (*d*)
21. [200]	22. (*c*)	23. (*c*)	24. (*c*)	25. (*b*)	26. [5418]	27. [25]	28. [143]	29. [46]	30. [24]
31. [0]	32. [2]	33. [1143]	34. [225]	35. [30]	36. [530]	37. [3]	38. [1]	39. [464]	40. [2]
41. [13]	42. [18]	43. [3400]	44. [496]	45. [2130]	46. (*d*)	47. (*c*)	48. (*b*)	49. [65]	50. [12]
51. (*a*)	52. [1655]	53. (*a*)	54. [14]	55. (*d*)	56. (*a*)	57. [56]	58. [11]	59. (*d*)	60. (*d*)
61. [2]	62. [13]	63. [18]	64. [46]	65. [34]	66. (*a*)	67. [3]	68. [78]	69. (*d*)	70. (*d*)
71. [138]	72. (*c*)	73. [45]	74. [153]	75. [420]	76. [8]	77. [50]	78. [2]	79. [24]	80. (*b*)
81. [591]	82. [20]	83. (*b*)	84. [9]	85. [318]	86. [80]	87. [45]	88. [95]	89. (*a*)	90. (*a*)
91. [100]	92. [44]	93. [12]	94. [4]	95. [227]	96. [1]	97. [224]	98. [3]	99. (*c*)	100. (*c*)
101. (*c*)	102. [1]	103. [2]	104. [25]	105. [2]	106. [63]	107. [77]	108. [8]	109. [16]	110. [78]
111. [80]	112. [18]	113. [19]	114. (*d*)	115. (*b*)	116. (*b*)	117. [69]	118. (*c*)	119. (*)	120. (*c*)

JEE-ADVANCED

1. (*a*)	2. (*d*)	3. (*d*)	4. (*b*)	5. (*a*)	6. (*d*)	7. (*a*)	8. [2500]	9. [6.15]	
10. [2.98 or 2.99]		11. [9]	12. [8]	13. [8]	14. [0.4]	15. [6.023×10^{24}]		33. (*a*)	34. (*a*)
35. (*a*)	36. (*c*)	37. (*b, c*)	38. [222]	39. [2.385]	40. [6.47]	41. [495]	42. [3]	43. [7/3]	44. [4.14
45. C-12 isotopes									

EXPLANATIONS

JEE-Main

1. (*b*) Weight is the force of gravity on an object, while mass is the amount of matter.

2. (*b*) The candela is the luminous intensity of a source that emits monochromatic radiation of $\nu = 540 \times 10^{12}$ Hz, and has a radiant intensity in that direction of $\frac{1}{683}$ w/sr. It is unit of Candela.

   Hence, *A* and *B* are 540 and 683 respectively.

3. (*c*) To determine the no. of significant figures certain rules are followed. According to the given options rules are mentioned as,

   (A) 0.00253
   Zeros to the left of first non-zero digits are not significant.
   Significant figures = 3(2, 5, 3)

   (B) 1.0003
   Zeros between non-zero digit are significant.
   Thus, 1.0003 has 5 significant figures.

   (C) 15.0
   If a number ends in zeros and if these zeros are to the right of a decimal point, then it will be significant.
   Significant figures = 3

   (D) 163
   All non zero digits are significant.
   Significant figures = 3
   Hence, number given in A, C and D have same significant figures.

4. (*b*) The given expression using the rules for significant figures can be solved as:

   $$\frac{0.02858 \times 0.112}{0.5702} = 0.00561$$

5. [3] In 0.00340, number of significant figure is 3.

6. [8] The no of significant figure in the given number is 8.

7. (*a*) In compound atoms of different elements combine in fixed ratio by mass & not in any ratio.

8. (*d*) (B) Matter consists of indivisible atoms.
   (D) All the atoms of given element have same properties including mass.

9. (*b*) ^{35}Cl
   Molar ratio be x
   Average molar mass
   $$= \frac{n_1M_1 + n_2M_2}{n_1 + n_2}$$
   M_{avg} $35 \times x + 37(1 - x) = 35.5$
   $35x + 37 - 37x = 35.5$
   $2x = 1.5$
   $x = 0.75; 1 - x = 0.25$
   So, ratio of $^{35}Cl : {}^{37}Cl = \frac{0.75}{0.25} = 3:$

10. [1]
    $NaI_{(aq)} + AgNO_{3(aq)} \rightarrow AgI_{(s)} + NaN$
    20 mL (Excess) 4.74 g
    number of moles of I^- in NaI = nu
    moles of (I^-) in AgI = $\frac{4.74}{235}$
    number of moles of NaI = $\frac{4.74}{235}$
    Molarity [NaI] = $\frac{4.74}{235 \times 0.02} = 1.$

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11. [63] $CaCO_3 \rightarrow CaO + CO_2$

Moles of $CaCO_3 = \frac{112500g}{100}$.

CaO produced from the reaction of $CaCO_3$ gives 1125 moles.

Mass of CaO $= \frac{1125 \times 56}{1000} = 63kg.$

12. (c) The reaction occurs as:

$Mg + 2HCl \rightarrow MgCl_2 + H_2$

Volume of hydrogen gas evolved = 220 ml

Moles of H_2 gas

= Volume of H_2 evolved/Volume at STP

$= \frac{220 \times 10^{-3}}{22.4} =$ Moles of Mg utilised

∴ Mass of Mg used = Moles of Mg used × Molar Mass of Mg

$\frac{220 \times 10^{-3}}{22.4} \times 24$

$= 235.7 \times 10^{-3}g$

= 235.7 mg

13. (b)

Number of atoms $= \frac{\text{Mass (g)}}{\text{Molar Mass (g / mol)}} \times N_A$

- $M_{Po} = 209$
- $\boxed{M_{Pr} = 141}$
- $M_{Pb} = 207$
- $M_{Pt} = 195$

Since Pr has the smallest atomic mass among the given elements, it will have the highest number of atoms in 10^{-9} grams.

14. [372] Molar mass of the given compound = 372 g

i.e., 1 mol of the compound weigh = 372 g

∴ 0.1 mol of the compound will weigh

$= \frac{372}{0.1} g = 372 \times 10^{-1} g$

15. (a) No. of moles of carbon

$= n_{CO_2} = \frac{1.46}{44} = 0.033$ moles

Mass of carbon = 0.033 × 12 = 0.396 g

No. of moles of hydrogen atom

$= 2 \times n_{H_2O} = 2 \times \frac{0.567}{18} = 0.063$

Mass of hydrogen atom = 0.063 × 1

= 0.063 g

Mass of oxygen atom

$= 1 - (M_{carbon} + M_{hydrogen})$

= 1 – (0.396 + 0.063)

= 1 – 0.459 = 0.541 g

No. of mole of oxygen atom

$= \frac{0.541}{16} = 0.033$

∴ Empirical formula of compound = CH_2O

Hence, empirical formula mass

= 12 + 2 + 16 = 30 g

16. [100] Organic compound

$\xrightarrow{\text{Combustion}} H_2O$

0.9 gm

So, $n_{H_2O} = \frac{w_{H_2O}}{M_{H_2O}} = \frac{0.9}{18} = 0.05$ mole

So, mole of H in $H_2O = 0.05 \times 2 = 0.1$ mole.

So, 0.01 mole of organic compound which contain 10% Hydrogen produce 0.1 mole of H.

So, 0.01 mole of organic compound produce = 10 mole of H = 10 g of H.

So, wt % of H

$= \frac{\text{wt of H in 1mole compound}}{\text{Molar mass of compound}} \times 100$

$10 = \frac{10}{M} \times 100$

M = 100 g/mol.

17. (d) Remaining moles of $CO_2 = 2.8 \times 10^{-3}$ moles

Removed molecules of $CO_2 = 10^{21}$ molecules

Now,

Removed moles of CO_2

$= \frac{10^{21}}{6.02 \times 10^{23}} = 1.66 \times 10^{-3}$ moles

Therefore, initial moles of CO_2

$= 2.8 \times 10^{-3} + 1.66 \times 10^{-3}$

$= 4.46 \times 10^{-3}$ moles

Hence, the mass of CO_2 taken initially is

$= 4.46 \times 10^{-3} \times 44 = 0.1962$ g = 196.2 mg

18. [11] Volume of silver coating = 0.05 × 0.05 × 10000 = 25 cm^3

Mass of silver deposited = 25 × 7.9 g

$\left(\therefore d = \frac{\text{mass}}{\text{volume}}\right)$

Moles of silver atoms $= \frac{25 \times 7.9}{108}$

Number of silver atoms

$= \frac{25 \times 7.9}{108} \times 6.023 \times 10^{23}$

$= 11.01 \times 10^{23}$

19. (d) 22.4 L of O_2 at STP → 1 mole

2.8375 L of O_2 at STP

$= \frac{2.8375}{22.4} = 0.125$ moles

⇒ Number of molecules = 0.125 N_A = 7.525×10^{22}

20. (d) $n = \frac{\text{Weight}}{\text{Molar mass}}$

16g CH_4 = 1 mole CH_4

1 mole $CH_4 \rightarrow 10 \times 6.02 \times 10^{23}$ electrons

$= 60.2 \times 10^{23}$ electrons

1g H_2 = 0.5 mole H_2

1 mole H_2 at STP → 22.4 L

0.5 mole H_2 at STP → 11.2 L ≈ 11.4 L

1 mole of N_2 = 28 g

($\because M_{N_2}$ = 28 g/mol)

0.5 mole of SO_2 = 32 g

($\because M_{SO_2}$ = 64 g/mol)

21. [200]

Let M is the molar mass of the compound (g/mol)

mass of compound = 0.01 M gm

mass of carbon $= 0.01M \times \frac{60}{100}$

moles of carbon $= \frac{0.01M}{12} \times \frac{60}{100}$

moles of CO_2 from combustion $= \frac{4.4}{44}$

= moles of carbon

$\frac{0.01M}{12} \times \frac{60}{100} = \frac{4.4}{44}$

$M = \frac{4.4}{44} \times \frac{100}{60} \times \frac{12}{0.01} = 200$gm/mol

22. (c) Molar mass of Fe_3O_4 = 232 g/mol

Molar mass of CO = 28 g/mol

Moles $= \frac{\text{Given weight}}{\text{Molar mass}}$

Moles of $Fe_3O_4 = \frac{4.64 \times 10^3}{232} = 20$

Moles of CO $= \frac{2.52 \times 10^3}{28} = 90$

According to the reaction:

4 moles of CO reacts with 1 mol of Fe_3O_4

⇒ 90 moles of CO reacts with 22.5 mole of Fe_3O_4

Thus, limiting reagent = Fe_3O_4

Thus, moles of Fe formed = 60

Weight of Fe = 60 × 56 = 3360g

23. (c) $SO_2Cl_2 + 2H_2O \rightarrow H_2SO_4 + 2HCl$

(Given: Moles of NaOH required for complete neutralisation = 16)

Let a moles of SO_2Cl_2 is taken

Then no. of moles of H_2SO_4 = a moles

No. of moles of HCl = 2a moles

No. of moles of NaOH required = 2a + 2a = 4a = 16 ⇒ a = 4 moles

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24. (c) Number of iron atoms in 3.3 g of hemoglobin

$= \frac{0.34}{100} \times \frac{3.3}{56} \times 6.022 \times 10^{23} = 1.206 \times 10^{20}$

25. (b) $C_6H_{12}O_6 \longrightarrow$ Glucose

$\% \text{ of C} = 10.8 = \frac{\text{Mass of C}}{\text{mass of solution}} \times 100$

$\text{Mass of C} = \frac{10.8 \times 250}{100} = 27\text{g}$

$\therefore$ Mass of glucose = 67.5 gm

$\therefore$ Moles of glucose = 0.375 moles

Mass of solvent = 250 – 67.5 = 182.5 gm

$\therefore$ Molality $= \frac{0.375}{0.1825} = 2.06$ m

26. [5418] Molar mass of

$C_7H_5N_3O_6 = (12 \times 7) + (1 \times 5) + (14 \times 3) + (16 \times 6) = 84 + 5 + 42 + 96 = 227\text{g/mol}$

Number of moles

$= \frac{\text{given wt}}{\text{molar mass}} = \frac{681}{227} = 3$ mol

$\therefore$ Number of N-atoms:

$= 3 \times 6.02 \times 10^{23} \times 3 = 9 \times 6.02 \times 10^{23}$

$= 54.18 \times 10^{23} = 5418 \times 10^{21}$

$\therefore x \times 10^{21} = 5418 \times 10^{21}$

$\therefore x = 5418$

27. [25] It is given that 0.30 gm glycine is present in 100 gm protein

So, 75 gm glycine is present in $\frac{100}{0.30} \times 75$

$= 25 \times 10^3$ g/mol

28. [143] $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

Mole $\frac{100}{16}$ $\frac{208}{32}$ $\left(\text{Moles} = \frac{\text{Mass}}{\text{Molar mass}}\right)$

$\downarrow$ $\downarrow$

6.25 6.5 (Here, O_2 is the limiting reagent)

Mole of CO_2 formed $= \frac{6.5}{2}$

Mass of CO_2 in gm $= \frac{6.5}{2} \times 44 = 143$ g

29. [46] $N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$

t = 0	56L	Excess
0	–10L	+20L
Final	46L	20L

Vol. of $N_2(g)$ remained unreacted = 46L

Vol. of N_2 used = 10L

30. [24] Mass of solute $= 48 \times 2 \times 10^{-3}$ gram

$\left(\because \text{ppm} = \frac{\text{mass of solute}}{\text{mass of solution}} \times 10^6\right)$

Atoms of Mg $= 24.08 \times 10^{20}$

31. [0] 50% of 0.02mmol and 1L of H_2SO_4 = 0.01 m mol

Total moles of H_2SO_4 after adding 0.01 mol of H_2SO_4

= 0.01 + 0.01 = 0.02 m mol

$= 0.00002 \times 10^3$ m mol

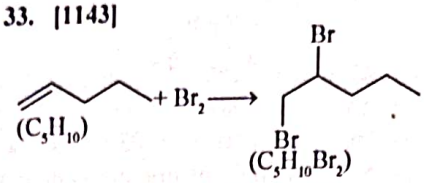
32. [2] According to question, molecular weight of A_2B = Molecular weight of AB_3

Thus, 2A + 3 = A + 3B

$\Rightarrow$ A = 2B

Hence, atomic weight of A is two times of atomic weight of B.

33. [1143]



Moles of Br_2 = moles of C_5H_{10}

$\therefore \frac{w}{160} = \frac{5}{70}$ (Molar mass of C_5H_{10} = 70 g/mol)

$\therefore w = \frac{5 \times 160}{70} = \frac{80}{7}$ g

= 11.428 g

$= 1142.8 \times 10^{-2} \approx 1143 \times 10^{-2}$ g

34. [225] $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

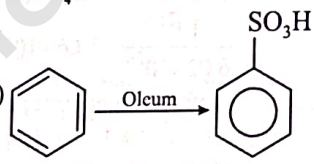
According to the reaction, 2 mol H_2O = 1 mol CH_4

or 36 gm of water = 1 mol CH_4

81 gm of $H_2O = \frac{1 \times 81}{36} = 2.25$ mol

Moles of $CH_4 = 225 \times 10^{-2}$ mol

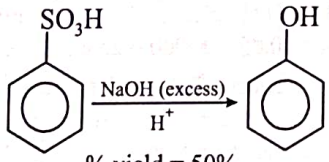
35. [30] (I)



% yield = 60%

Let initial moles of reactant be = n. Total moles of benzene sulphonic acid = 0.6 n

(II)



% yield = 50%

Moles of benzene sulphonic acid before reaction II = 0.6n.

Moles of phenol (with % yield 50%) = 0.6 × 0.5 n = 0.3n

So, overall % age yield

$= \frac{0.3n}{n} \times 100 = 30\%$

36. [530] According to the given condition,

No. of moles of toluene reacted

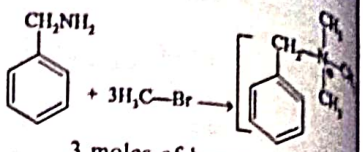
$= \frac{5}{92} \times \frac{92}{100} = 5 \times 10^{-2}$

Mass of benzaldehyde obtained

$= n \times \text{molar mass} = 5 \times 10^{-2} \times$

$= 530 \times 10^{-2}$ g

37. [3] Step 1:



3 moles of bromomethane is ... to form 1 mole of benzyl tri... ammonium bromide

Step 2: To calculate no. of ... benzyl trimethyl ammonium ... present in 23 g

M.wt of $(C_{10}H_{16}NBr)$

$= 12 \times 10 + 1 \times 16 + 1 \times 14 + 1 \times 80$

No. of moles in 23 g $= \frac{23}{230} = 0.1$

For 1 mole product $\rightarrow$ 3 mole ... required

So for 0.1 mole product $\rightarrow$ 0.3 ... CH_3Br is required

$n = 3 \times 10^{-1}$ mole

n = 3

38. [1] Total wt = 4 gm = $W_{NaOH} + W$

Let m be the moles for each.

4 = 40 m + 106 m (Here, 40 ... are molar masses of NaOH and ... respectively)

$\therefore m = \left(\frac{4}{146}\right)$ mole of NaOH ... Na_2CO_3 each.

$\therefore$ Mass of NaOH (x gm)

$= \frac{4}{146} \times 40 = 1.095 \approx 1.0$

39. [464]

The combustion reaction of butane ...

$C_4H_{10} + \frac{13}{2}O_2 \longrightarrow 4CO_2 + 5H_2O$

1 mole C_4H_{10} = 5 mole H_2O

$\therefore$ 5 mole $H_2O = 5 \times 18 = 90$ gm

$\because$ 90 g H_2O obtained from 58 g ...

$\therefore$ 72g H_2O obtained from $\frac{58}{90} \times 72$

$= \frac{58}{90} \times 72\text{g} = 46.4 = 464 \times 10^{-1}$ g

40. [2] Moles of sodium

$= \frac{\text{Mass}}{\text{Molar Mass}} = \frac{8}{23}$ mol

Number of atoms $= \frac{8}{23} \times 6.02 \times$

$= 2.09 \times 10^{23} \approx 2 \times 10^{23}$

41. [13] Mass of Na^+ in 50 mL = 70 ×

= 3500mg

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23000 mg of Na^+ = 85000 mg of $NaNO_3$
(1 mole $NaNO_3$ contains 1 mole Na^+)
∴ 3500 mg Na^+ will be present in $\frac{85000}{23000} \times 3500$
= 12934.78 mg = 12.93478 gm ≅ 13

42. [18] The combustion reactions of propane and butane are:

$$C_3H_8 + 5O_2 \longrightarrow 3CO_2 + 4H_2O$$

$$C_4H_{10} + \frac{13}{2}O_2 \longrightarrow 4CO_2 + 5H_2O$$

∵ 2 mol C_4H_{10} is given
∴ 13 mol O_2 is needed for combustion of Butane.
∴ Total moles of O_2 = 5 + 13 = 18

43. [3400] $N_2 + 3H_2 \longrightarrow 2NH_3$

$\frac{2.8\times10^3}{28}$ $\frac{1\times10^3}{2}$

0.1×10^3 mol 0.5×10^3 mol

N_2 is a limiting reagent.
Now, mass of NH_3 produced = moles × molar mass
$0.2 \times 10^3 \times 17 = 3.4$ kg = 3400 g

44. [496] Ferrous sulphate heptahydrate is $FeSO_4 \cdot 7H_2O$.

$$PPM = \frac{\text{Mass of Iron}}{\text{Mass of Wheat}} \times 10^6$$

$$10 = \frac{\text{Mass of Iron}}{100\times10^3} \times 10^6$$

Mass of Fe = 1 gm

Mole of Fe = $\frac{1}{56}$

$FeSO_4\ 7H_2O$ contain = 1 mole of Fe atom
∴ 56 g in 1 mole

1 g in $\frac{1}{56}$ mole

∴ Mass = $\frac{1}{56} \times 277.85 = 496$

45. [2130] Acc. to reaction, moles of $NaClO_3$ = moles of O_2

Moles of O_2 = $\frac{1\times492}{0.082\times300}$ = 20 mole

(∵ $n = \frac{PV}{RT}$)

Mass of $NaClO_3$ = 20 × 106.5 = 2130 g.

46. (*d*) $C_xH_y + \left(x+\frac{y}{4}\right)O_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$

10 $10\left(x+\frac{y}{4}\right)$ 10x

By given data, $10\left(x+\frac{y}{4}\right) = 55$ ...(i)

10x = 40 ...(ii)

∴ x = 4, y = 6 ⇒ C_4H_6

47. (*c*) $5[M_A + 2M_B] = 125$

$M_A + 2M_B = 25$ ...(i)

$2M_A + 2M_B = 30$ ...(ii)

from eq. (i) & (ii)

$M_A = 5$

$M_B = 10$

48. (*b*)

$$\underset{0.210\text{ gm}}{C_xH_yO_z} + O_2 \longrightarrow \underset{0.307\text{ gm}}{CO_2} + \underset{0.127\text{ gm}}{H_2O}$$

Weight of C in CO_2

$= \frac{0.307\times12}{44} = 0.0837$g

Weight of H in H_2O

$= \frac{0.127\times2}{18} = 0.0141$g

Weight of O = 0.210 – (0.0837 + 0.0141)
= 0.1122 g

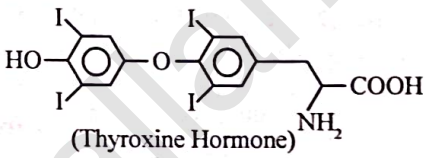
The percentage of hydrogen

$= \frac{0.0141}{0.210} \times 100 = 6.72\%$

The percentage of oxygen

$= \frac{0.1122}{0.210} \times 100 = 53.41\%$

49. [65]



(Thyroxine Hormone)

The molecular formula of Thyroxine
⇒ $C_{15}H_{11}O_4NI_4$

Molecular mass of Thyroxine –
C → 15 × 12 = 180
H → 11 × 1 = 11
O → 16 × 4 = 64
N → 14 × 1 = 14
I → 127 × 4 = 508

The total molecular mass of thyroxine is:
180 + 11 + 64 + 14 + 508 = 777

Percentage of Iodine = $\frac{508}{777} \times 100$
= 65.38 %

Nearest integer = 65

50. [12]

Organic compound $\xrightarrow[\Delta]{CuO} CO_2 + H_2O$

no. of moles of CO_2 = $\frac{220\times10^{-3}}{44}$
$= 5 \times 10^{-3}$ moles

mass of carbon = $5 \times 10^{-3} \times 12$

Percentage mass of carbon

$= \frac{5\times10^{-3}\times12}{500\times10^{-3}} \times 100 = 12\%$

51. (*a*)

Element	Moles	Molar ratio	Simplest ratio
C	54.2	54.2/12 = 4.5	4.5/2.28 = 2
H	9.2	9.2/1 = 9.2	9.2/2.28 = 4
O	36.6	36.6/16=2.28	2.28/2.28 = 1

Empirical formula = C_2H_4O

Empirical formula mass
= 12 × 2 + 4 + 16 = 44

$n = \frac{\text{molecular mass}}{\text{empirical formula mass}} = \frac{132}{44} = 3$

Molecular formula = n × E.F = 3(C_2H_4O)
= $C_6H_{12}O_3$

52. [1655]

Element	%	Moles	Ratio	Simplest Ratio
C	14.5	1.2 mol	1	2
H	1.8	1.8 mol	1.5	3
Cl	64.46	1.8 mol	1.5	3
O	19.24	1.2 mol	1	2

∴ Empirical formula is $C_2H_3O_2Cl_3$

Molar mass = 165.5 g mol^{-1}
= 1655×10^{-1} g mol^{-1}

∴ Answer is 1655.

53. (*a*) $CaCO_3(s) \xrightarrow{\Delta} CaO(s) + CO_2(g)$

$MgCO_3(s) \xrightarrow{\Delta} MgO(s) + CO_2(g)$

Let the weight of $CaCO_3$ be x g
∴ weight of $MgCO_3$ = (2.21 – x) g
Moles of $CaCO_3$ decomposed = moles of CaO formed

$\frac{x}{100}$ = moles of CaO formed

∴ weight of CaO formed = $\frac{x}{100} \times 56$

Moles of $MgCO_3$ decomposed
= moles of MgO formed

$\frac{(2.21-x)}{84}$ = moles of MgO formed

∴ weight of MgO formed

$= \frac{2.21-x}{84} \times 40$

$\Rightarrow \frac{2.21-x}{84} \times 40 + \frac{x}{100} \times 56 = 1.152$

∴ x = 1.1886 g = weight of $CaCO_3$
& weight of $MgCO_3$ = 1.0214 g

54. [14] $\underset{10ml}{C_xH_y} + O_2 \rightarrow CO_2 + H_2O$

$C_xH_y + \left(x+\frac{y}{4}\right)O_2 \rightarrow \underset{10x}{xCO_2} + \underset{5y}{\frac{y}{2}H_2O}$

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According to chemical reaction,

$10x = 40$

$x = 4$

$5y = 50$

$y = 10$

C_4H_{10}

55. (*d*) Only $C_{12}H_{22}O_{11}$ has 42.1% carbon, 6.4% hydrogen & 51.5% oxygen.

56. (*a*) Molecular weight of metal chloride

Given: mass of metal chloride = 0.57g

$= \frac{0.57}{100} \times 22700 = 129.39$

weight of Cl = 129.9 × 0.55 = 71.1645

$\therefore$ Mole of Cl $= \frac{71.1645}{35.5} \cong 2$

Hence, metal chloride is MCl_2

57. [56] Moles of $CO_2 = \frac{0.22}{44} = \frac{1}{200}$

(molar mass = of CO_2 = 44g/mol)

$\therefore$ Moles of carbon = (Moles of CO_2) × number of C atoms in it

$= \frac{1}{200} \times 1 = \frac{1}{200}$

$\therefore$ % wt. of C $= \frac{1}{200} \times 12 = 0.06$

% of C $= \frac{0.06}{W} \times 100 = 24$

Moles of $H_2O = \frac{0.126}{18} = 0.007$

(Molar mass of H_2O = 18g/mol)

$\therefore$ Moles of H atom = (moles of H_2O) × 2

$= 2 \times 0.007 = 0.014$

Thus, % of H $= \frac{0.014 \times 1}{W} \times 100$

$= 5.6 = 56 \times 10^{-1}$

58. [11] Percentage of Carbon

$= \frac{12}{44} \times \frac{\text{mass of } CO_2 \text{ formed}}{\text{mass of compound taken}} \times 100$

$60 = \frac{12}{44} \times \frac{\text{mass of } CO_2 \text{ formed}}{0.5} \times 100$

Mass of CO_2 formed $= \frac{60 \times 44 \times 0.5}{12 \times 100}$ g

$= 1.1$ gram $= 11 \times 10^{-1}$ gram

59. (*d*) Number of moles of C = Number of moles of CO_2 = $= \frac{\text{Given weight}}{\text{Molar mass}} = \frac{330}{44}$ moles

Number of moles of H = 2 × no. of moles of $H_2O = \left(\frac{270}{18} \times 2\right)$ moles

Mass of C $= \frac{330}{44} \times 12$ gm = 90 gm

Mass of H $= \frac{270}{18} \times 2 \times 1$ gm = 30 gm

% of C $= \frac{90}{120} \times 100\% = 75\%$

% of H $= \frac{30}{120} \times 100\% = 25\%$

60. (*d*) The empirical formula for the compound A can be calculated as:

	Mass	$= \frac{\text{Moles}}{\text{Weight}}$ / Molar Mass	Simplest Ratio
C	74g	$\frac{74}{12} = 6.17$	$\frac{6.17}{1.24} = 4.9 \approx 5$
H	8.7g	$\frac{8.7}{1} = 8.7$	$\frac{8.7}{1.24} = 7$
N	17.3g	$\frac{17.3}{14} = 1.24$	$\frac{1.24}{1.24} = 1$

Hence, empirical formula is C_5H_7N and empirical mass is 81 g/mol

Given: Molecular mass = 162 g/mol

$\Rightarrow n = \frac{\text{Molecular Mass}}{\text{Empirical Mass}} = \frac{162}{81} = 2$

Molecular formula = n × Empirical formula $= C_{10}H_{14}N_2$

61. [2] The empirical formula of the given compound can be calculated as:

% of element $= \frac{\text{Amount of element}}{\text{Amount of substance}} \times 100$

Hence, % of C $= \frac{48.5}{116} \times 100 = 41.8\%$

% of H $= \frac{7.5}{116} \times 100 = 6.5\%$

% of O $= \frac{60}{116} \times 100 = 51.7\%$

	Mass	Moles $= \frac{w}{m}$	Simplest Ratio
C	41.8g	$\frac{41.8}{12} = 3.48$	$\frac{3.48}{3.23} \approx 1$
H	6.5g	$\frac{6.5}{1} = 6.5$	$\frac{6.5}{3.23} \approx 2$
O	51.7g	$\frac{51.7}{16} = 3.23$	$\frac{3.23}{3.23} = 1$

Given the ratio of moles of C, H and O is 1 : 2 : 1

A. $CH_3COOH \Rightarrow$ C : H : O = 2 : 4 : 2 = 1 : 2 : 1

B. HCHO $\Rightarrow$ C : H : O = 1 : 2 : 1

C. $CH_3OOCH_3 \Rightarrow$ C : H : O = 2 : 6 : 2 = 1 : 3 : 1

D. $CH_3CHO \Rightarrow$ C : H : O = 2 : 4 : 1

So, only two compounds CH_3C HCHO agrees with given data.

62. [13] $MnO_2 + HCl \longrightarrow MnCl_2 +$

$Cl_2 + 2KI \longrightarrow 2KCl + I_2$

$I_2 + 2Na_2S_2O_3 \longrightarrow 2NaI + Na$

Now, meq of MnO_2 = meq of

$\frac{W}{E} \times 1000 = M \times$ n–factor × V

$\frac{W}{87/2} \times 1000 = 0.1 \times 1 \times 60$

Mass of MnO_2 in sample = 0.2

Given, MnO_2 = 2g

% of MnO_2 in sample = $\frac{0.2}{2}$

= 13.05%

Hence, 13% MnO_2 is present in th

63. [18] Calculate wt of carbon in 0.2 as:

$= \left(\frac{12}{44} \times 0.2\right)$ gm

Therefore % of carbon in comp

$= \frac{\text{wt of carbon} \times 100}{\text{wt of compound}} = \frac{12 \times 0.2}{44 \times}$

$= \frac{2400}{44 \times 3} = 18.18 \approx 18\%$

64. [46] Moles of C = moles of CO_2

$= \frac{\text{Weight of } CO_2}{\text{Molar mass of } CO_2} = \frac{0.793}{44}$

Mass of C = Moles of CO_2 × Mol of C $= \frac{0.793}{44} \times 12g = 0.216g$

Moles of H $= 2 \times \frac{0.442}{18}$ mol

Mass of H $= 2 \times \frac{0.442}{18} \times 1g = 0.$

Given: Total mass of compound =

So; mass of O = (0.492 – 0.216 –

= 0.227g

% of O $= \frac{\text{Mass of oxygen}}{\text{Total mass of compoun}}$

$= \frac{0.227}{0.492} \times 100 = 46.14\% \approx 46\%$

65. [34] Given: Mass of organic co = 0.5g

Moles of AgBr $= \frac{0.40}{188}$ moles

Now, moles of Br in organic co = Moles of Br in AgBr = Moles

$= \frac{0.4}{188}$ mol

Mass of Br in organic compound

of Br × Atomic weight of Br = $\frac{0.}{18}$

Hence, % of Br $= \frac{0.4 \times 80}{188 \times 0.5} \times 10$

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66. (*a*) First calculate the percentage of C and H as:

% of C

$$= \frac{\text{Wt of } CO_2}{\text{Wt of comp.}} \times \frac{12}{44} \times 100$$

$$= \frac{2.64}{1.8} \times \frac{12}{44} \times 100 = 40\%$$

% of H

$$= \frac{\text{Wt of } H_2O}{\text{Wt of comp.}} \times \frac{2}{18} \times 100$$

$$= \frac{1.08}{1.8} \times \frac{2}{18} \times 100 = 6.67\%$$

Now, % of O = 100 – (40 + 6.67) = 53.33%

67. [3] Moles of carbon in organic compound = Moles of carbon in CO_2

$$n_C = n_{CO_2} = \frac{\text{Given weight of } CO_2}{\text{Molar mass of } CO_2}$$

$$= \frac{420}{44} \text{ moles}$$

Mass of carbon in organic compound = Moles of C × Atomic weight of C = $\frac{420}{44} \times 12 = 114.54$g

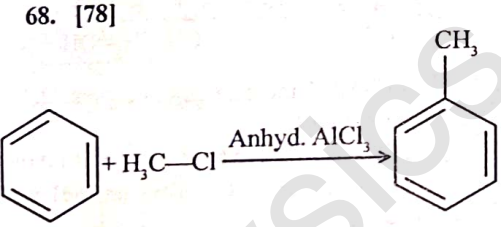
Moles of hydrogen in compound = moles of hydrogen in H_2O

Thus, $n_H = n_{H_2O} = 2 \times \frac{210}{18}$ moles

Mass of hydrogen = $2 \times \frac{210}{18}$ g = 23.33g

Thus, % of H = $\frac{23.33}{750} \times 100 = 3.11\% \approx 3$.

68. [78]



Theoretically; 1 mol benzene of 1 mol will give 1 mol of toluene.

Moles of benzene = $\frac{10}{78}$ mol

Moles of toluence (Theoretical) = $\frac{10}{78}$ mol

Mole of toluene (observed) = $\frac{9.2}{92} = 0.1$ mol

$$\% \text{ yield} = \frac{\text{Observed moles}}{\text{Theoretical moles}} \times 100$$

$$\% \text{ yield} = \frac{0.1}{\frac{10}{78}} \times 100 = 78\%$$

69. (*d*) In CH_4

1 mole for 'C' and 4 mole for 'H'

Total 5 mole atom

% by mole of carbon = $\frac{1 \text{ mol atom}}{5 \text{ mol atom}} \times 100$ = 20%

70. (*d*) $2NaHCO_3 + H_2C_2O_4 \rightarrow Na_2C_2O_4 + 2CO_2 + 2H_2O$

Let mass of $NaHCO_3$ be x mg

$$n_{CO_2} = \frac{0.25}{25000} = 10^{-5}$$

$$w_{NaHCO_3} = 84 \times 10^{-5} \text{g}$$

$$\% = \frac{84 \times 10^{-5}}{10^{-2}} \times 100 = 8.4\%$$

71. [138]

- The balanced reaction for butane combustion is:

$$C_4H_{10} + \frac{13}{2}O_2 \rightarrow 4CO_2 + 5H_2O$$

- Moles of butane = $\frac{174000}{58}$ = 3000 mol.

Moles of O_2 = $\frac{320000}{32}$ = 10000 mol

According to the reaction

1 mol C_4H_{10} requires $\rightarrow \frac{13}{2}$ mole of O_2

3000 mol C_4H_{10} requires $\rightarrow$ 19500 moles of O_2.

But we have 10,000 moles of O_2.

∴ O_2 is the L.R.

Again, according to the reaction $\frac{13}{2}$ moles of $O_2 \rightarrow$ 5 mol of H_2O

∴ 10,000 moles of O_2 will produce

$\rightarrow 5 \times \frac{2}{13} \times 10{,}000$ mol of $H_2O = \frac{10^5}{13}$

Mass of H_2O formed = $\frac{10^5}{13} \times 18$

= 1.3846×10^5 g

∴ Volume of H_2O formed will be = 1.3846×10^5 mL (ρ_{H_2O} = 1 g/mL)

= 138.46 L

72. (*c*)

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$$

Moles of HCl = M × V (L)

$= 0.76 \times \frac{250}{1000} = 0.19$

Moles of $CaCO_3$ = Mass/molar mass

$= \frac{1000}{100} = 10$

Therefore, HCl is the limiting reagent.

According to the reaction, 2 moles of HCl forms = 1 mol of $CaCl_2$

∴ 0.19 moles of HCl will form = $\frac{0.19}{2}$ moles of $CaCl_2$

Hence, mass of $CaCl_2$ formed

$= \frac{0.19}{2} \times 111 = 10.545$ g

73. [45]

Let the number of moles of CO_2 be n

Initial moles of $Ca(OH)_2$ be 2n

Excess moles of $Ca(OH)_2$ be n

As,

gm equivalent of $Ca(OH)_2$ = gm equivalent of HCl

Thus, n × 2 = 0.1 × (40/1000) ×1

On solving,

n = 2 × 10^{-3}

Volume of CO_2 = 2 × 10^{-3} × 22400 = 44.8 cm^3

74. [153] $2Al + \frac{3}{2}O_2 \rightarrow Al_2O_3$

$$n_{Al} = \frac{w_{Al}}{M_{Al}} = \frac{81}{27} = 3 \text{ mole}$$

$$n_{O_2} = \frac{w_{O_2}}{M_{O_2}} = \frac{128}{32} = 4 \text{ mole}$$

According to stoichiometry of reaction, 2 mole of Al reacts with $\frac{3}{2}$ mole of O_2 and produce 1 mole of Al_2O_3.

So, 3 mole of Al will react with $\frac{9}{4}$ mole of O_2.

So, Al will be limiting reagent.

So, 3 mole of Al will form $\frac{3}{2}$ mole of Al_2O_3.

$$w_{Al_2O_3} = n_{Al_2O_3} \times M_{Al_2O_3}$$

$$w_{Al_2O_3} = \frac{3}{2} \times 102 = 153 \text{ g.t}$$

75. [420] Moles of Fe_3O_4

$$\text{Moles} = \frac{\text{Mass}}{\text{Molar Mass}} = \frac{2320 \times 10^3}{232}$$

$= 10^4$ moles

Moles of CO:

$$\text{Moles} = \frac{280 \times 10^3}{28} = 10^4 \text{ moles}$$

From the balanced equation: 1 mole of Fe_3O_4 reacts with 4 moles of CO

Thus, for 10^4 moles of Fe_3O_4, we need:

$10^4 \times 4 = 4 \times 10^4$ moles of CO

But we only have 10^4 moles of CO, which is less than required.

So, CO is the limiting reactant.

Mole of Fe = $\frac{3}{4} \times 10^4$

Mass of Fe = $\frac{3}{4} \times \frac{10^4 \times 56}{1000}$ kg = 420 kg

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76. [8] $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

Moles of $CO_2 = \frac{22}{44} = 0.5$ mole

So, required moles of $CH_4 = 0.5$ mole

Mass $= 0.5 \times 16 = 8$ gm

77. [50] $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(\ell)$

$n_{CO_2} = \frac{22}{44} = 0.5$ moles

So moles of CH_4 required = 0.5 moles

That is, 50×10^{-2} mole

x = 50

78. [2]

$$R\text{–}NH_2 + CH_3\text{–}\overset{\overset{\large O}{\|}}{C}\text{–}Cl \rightarrow R\text{–}NH\text{–}\overset{\overset{\large O}{\|}}{C}\text{–}CH_3$$

The gain in molecular weight after acylation with one $-NH_2$ group is 42.

The total increase in molecular weight is 84.

$\therefore$ Number of amino group in, $= \frac{84}{42} = 2$

79. [24] The limiting reagent in the reaction is $PbCl_2$.

mmol of $Pb_3(PO_4)_2$ formed

$= \frac{\text{mmol of PbCl reacted}}{3} = 24$ mmol

80. (*b*) $C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(\ell)$

No. of moles of glucose

$= \frac{900}{180} = 5$ mol

$\because$ 1 mol glucose require = 6 mol of O_2

$\therefore$ 5 mol glucose will require

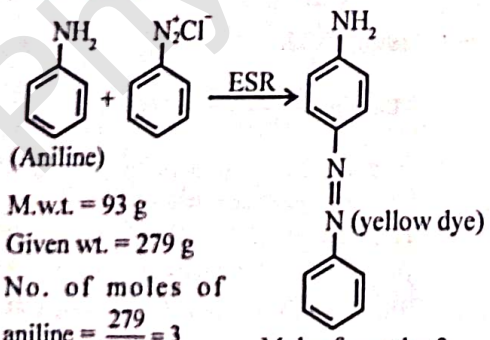
$= 6 \times 5$ mol of O_2

= 30 mol of O_2

$\therefore$ Mass of O_2 required

$= 30 \times 32 = 960$ g

81. [591]



(Aniline)

M.w.t. = 93 g

Given wt. = 279 g

No. of moles of aniline $= \frac{279}{93} = 3$

Moles formed = 3

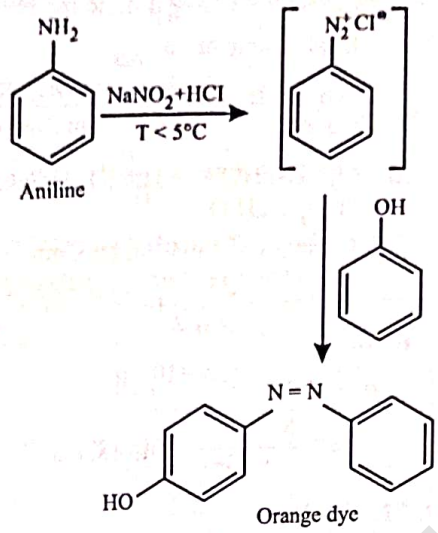
M.w.t. = 197

Amount formed

$= 197 \times 3 = 591$ g

Hence, the maximum amount of aniline yellow formed will be 591 g.

82. [20]



Aniline

According to the above reaction, 1 mole of aniline gives 1 mole of orange dye.

So $(n)_{aniline} = (n)_{orange\ dye}$

$n = \frac{\text{Given mass}}{\text{molecular mass}}$

Thus, $\frac{9.3g}{93g\ mol^{-1}} = \frac{\text{mass of orange dye}}{199g\ mol^{-1}}$

Hence, mass of orange dye = 19.9 g ≈ 2g

83. (*b*)

$$C_nH_{2n+2} + \frac{3n+1}{2}O_2 \longrightarrow nCO_2 + (n+1)H_2O$$

$$CH_4 + 2O_2 \rightarrow \underset{11gm}{CO_2} + 2H_2O$$

Number of moles of CO_2 = 11 mol/44 mol = 0.25 mol

According to the question, 1 mol of CO_2 is produced from 1 mol of CH_4.

Hence, 0.25 mole CH_4 gives 0.25 mole (or 11 g) CO_2.

84. [9] $HCl + NaOH \rightarrow NaCl + H_2O$

mol of HCl = 0.2 mol

0.2 mol HCl would be generated by 0.2 mol $C_2H_5NH_2$

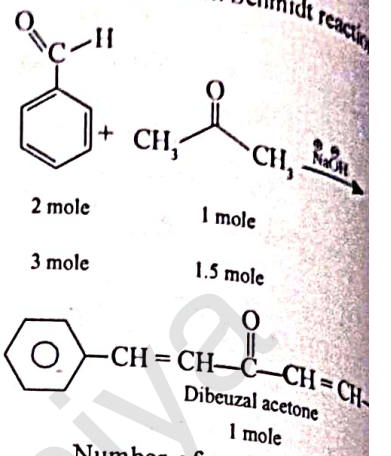
$$\underset{0.2\ mol}{CH_3\text{–}CH_2\text{–}NH_2} \xrightarrow{NaNO_2+HCl} CH_3\text{–}CH_2\text{–}\overset{\oplus}{N_2}\overset{\ominus}{Cl} \xrightarrow{HOH} CH_3\text{–}CH_2\text{–}OH + N_2 + \underset{\substack{(g)\\0.2\ mol}}{HCl}$$

MW of ethanamine = 45

$45 \times 0.2 = 9$ g

$x = 9$

85. [318] Claisen Schmidt reactio



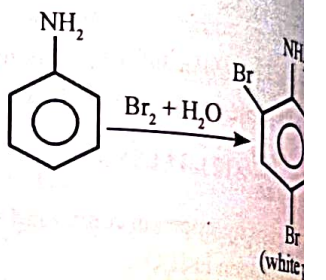
Number of moles of dibenz = 1.5 moles

M.W of benzaldehyde = 106 g

Weight of 3 moles of benzalde = 106 × 3 = 318 g.

Hence, 318 g benzaldehyde is r give 1.5 mole (or 351g) produc

86. [80]



93g aniline ⟶ 330 g of 2 tribromoa

9.3g aniline ⟶ 33 g of 2 tribromoa

% yield $= \frac{26.4}{33} \times 100 = 80$

87. [45]

$$\underset{\text{Mol.wt.45g}}{CH_3CH_2NH_2} \xrightarrow{NaNO_2+HCl} \xrightarrow{H_2O} CH_3CH_2\text{–}O$$

At STP, 1 mole of gas occupie of volume.

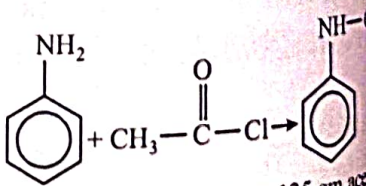
Given: N_2 evolved is 2.24 L i.e. 0

i.e. $CH_3CH_2NH_2$ (ethyl ami be 4.5 g

(= 0.1 mole)

Thus, $X = 45 \times 10^{-1}$ g.

88. [95] The reaction for the abo process is



$\because$ 93g aniline form 135 gm ac

$\therefore$ 6.55 g anilne will form $\frac{135}{93} \times 6$

$= 95 \times 10^{-1}$

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89. (a)

$$C_xH_y + \left(x+\frac{y}{4}\right)O_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$$

$x+\frac{y}{4}=9.5$

$\frac{y}{2}=3$ ($\therefore$ given 3 equivalents of water)

$\Rightarrow x=8, y=6$

90. (a) The general form of combustion reaction is:

$$C_xH_y + \left(x+\frac{y}{4}\right)O_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$$

$\frac{y}{2}=4 \therefore y=8 \Rightarrow x+\frac{8}{4}=11$

$\therefore x=9$

Hydrocarbon formula will be $= C_9H_8$

91. [100] The chemical reaction for treatment of carbonate with excees HCl is given as,

$$M_2CO_3 + \underset{\text{Excess}}{2HCl} \rightarrow \underset{0.02\text{ mole}}{2MCl} + H_2O + \underset{0.01\text{ mole}}{CO_2}$$

From principle of atomic conservation of carbon atom,

Mole of $M_2CO_3 \times 1 =$ Mole of $CO_2 \times 1$

$$\frac{1\text{gm}}{\text{molar mass of } M_2CO_3} = 0.01\times 1$$

$\therefore$ Molar mass of $M_2CO_3 = 100$gm/mole

92. [44] Weight of C in 0.792 gm CO_2

$=\frac{12}{44}\times 0.792 = 0.216$

% of C in compound $=\frac{0.216}{0.492}\times 100$

$= 43.90\%$

Hence, 44% carbon is present in the organic compound.

93. [12]

Element	Percentage	mole = $\frac{\text{weight}}{\text{molar mass}}$	Mole ratio
C	85.8	$\frac{85.8}{12}=7.15$	$\frac{7.15}{7.15}=1$
H	14.2	$\frac{14.2}{1}=14.2$	$\frac{14.2}{7.15}=2$

Hence, Empirical formula $= CH_2$

Now, $n = \frac{\text{molecular mass}}{\text{Empirical formula}} = \frac{84}{14} = 6$

$n=6$

$\therefore$ Molecular formula C_6H_{12}

Hence, 12 hydrogen atoms are present in per molecule of a hydrocarbon, A.

94. [4] The reaction takes place as follows:

$Zn + 2HCl \rightarrow ZnCl_2 + H_2$

Moles of Zn $= \frac{11.5}{65.4}$ moles

According to the reaction,

1 mole of Zn produces 1 mole of H_2 gas

Thus, $\left(\frac{11.5}{65.4}\right)$ moles of Zn produce $\left(\frac{11.5}{65.4}\right)$ moles of H_2 gas.

At STP

1 mol of H_2 produces 22.7 L of volume.

Hence, for $\left(\frac{11.5}{65.4}\right)$ moles of H_2, Volume

$=22.7\times\left(\frac{11.5}{65.4}\right)=3.99\text{L}=4\text{L}$

95. [227] $2C(s) + O_2(g) \rightarrow 2CO(g)$

1mol 1.5 mol

Here, C acts a limiting reagent.

1 mol C = 1 mol CO

Hence, volume at STP is 227×10^{-1} litre

96. [1]

$3BaCl_2 + 2Na_3PO_4 \rightarrow Ba_3(PO_4)_2 + 6NaCl$

5 2

$\frac{\text{number of moles}}{\text{stiochiometric coeffs}}$ less are the limiting reagent.

Na_3PO_4 is limiting reagent.

2 mole Na_3PO_4 gives 1 mole of $Ba_3(PO_4)_2$

97. [224] $Mg + 2HCl \rightarrow MgCl_2 + H_2\uparrow$ w = 2.4 g

$n=\frac{m}{M.M.}=\frac{2.4}{24}=0.1$ mole

1 mole of gas at STP $\Rightarrow$22.4 litre

$\therefore$0.1 mole of gas = 0.1 × 22.4

= 22.4 litre = 224×10^{-2} litre

98. [3] Moles of hydrocarbon

$=\frac{17\times10^{-3}}{136}=1.25\times10^{-4}$

Mole of H_2 gas

$\Rightarrow 1\times\frac{8.40}{1000}=n\times0.0821\times273$

$\Rightarrow n = 3.75 \times 10^{-4}$

Hydrogen molecule used for 1 molecule of hydrocarbon is 3.

$=\frac{3.75\times10^{-4}}{1.25\times10^{-4}}=3$

99. (c) Mass of $C_{15}H_{30}$ = volume × Density

= 1000 mL × 0.756 gm / mL = 756 gram

$C_{15}H_{30} + 22.5\,O_2 \longrightarrow 15CO_2 + 15H_2O$

No. of moles of $C_{15}H_{30}$ needed $=\frac{756}{210}$ moles

No. of moles of O_2 needed $=\left(22.5\times\frac{756}{210}\right)$ moles

Mass of O_2 needed $= 22.5 \times \frac{756}{210} \times 32$

= 2592 gm

No. of moles of CO_2 liberated

$=15\times\left(\frac{756}{210}\right)$ moles

Mass of CO_2 liberated $= 15 \times \frac{756}{210} \times 44$

= 2376 gm

100. (c) $4HNO_3(\ell) + 3KCl(s) \longrightarrow Cl_2(g) + NOCl(g) + 2H_2O(g) + 3KNO_3(s)$

According to the reaction 4 moles of HNO_3 gives 3 mol of KNO_3

Here, mole of produced $KNO_3 = \frac{110}{101}$

($\because M_{KNO_3}$=101g/mol)

If 3 mol of KNO_3 produced by 4 moles of HNO_3

$\therefore$ 1 mole of KNO_3 produced by $\frac{4}{3}$ moles of HNO_3 and $\frac{110}{101}$ mole of KNO_3 produced by $\frac{4\times110}{3\times101}$ moles of HNO_3

= 1.45 mole of HNO_3

Hence, the mass of HNO_3 = mole × molecular weight = 1.45 × 63 = 91.48 ≈ 91.5 g

101. (c) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

At t = 0 $\frac{20}{28}$ $\frac{5}{2}$ 0

According to the reaction,

3 moles of H_2 require → 1 mole of N_2

$\frac{5}{2}$ moles of H_2 require → 5 mole of N_2

Hence, N_2 is the limiting reagent in the given reaction and number of moles of $NH_3 = 2 \times$ number of moles of N_2 reacted

$=2\times\frac{20}{28}=\frac{40}{28}=1.42$ moles

102. [1] No. of equivalents of 0.1 M H_2SO_4

= 100 × 0.1 × 2 = 20

No. of equivalents of 0.1 M NaOH

= 50 × 0.1 = 5

No. equivalents of H_2SO_4 left = 20 – 5 = 15

150 × x = 15

$x=\frac{1}{10}=0.1\text{N}=1\times10^{-1}\text{N}$

103. [2] $X + Y + 3Z \rightleftharpoons XYZ_3$

1 mole 1mole 0.05 mole

$\therefore n_X = 1$

$n_Y = 1$

$n_X = \frac{0.05}{3} = 0.0167$

(Here, Z acts as a limiting reagent).

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$\because \frac{0.05}{3}$ mole Z gives 1 mole XYZ_3

$\therefore$ Mass of XYZ_3 = n × molecular mass

$= \frac{0.05}{3} \times 120 = 0.05 \times 40 = 2g$

104. [25] $H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$

No. of mole = 0.2 × 2

2 × 0.1 – = 0.4 = 0.2

No. of moles after reaction

= 0.4 – 0.1 0.2 – 0.2 0.1

= 0.3 = 0

$\therefore$ Molarity of Na_2SO_4

$= \frac{\text{Moles}}{V(L)} = \frac{0.1}{4}$

= 0.025 = 25 mM

105. [2] Mass of charcoal = 0.6g

Mass of acetic acid adsorbed

$= \frac{M_1V_1 - M_2V_2}{1000} \times 60$

$= \frac{0.2 \times 200 - 200 \times 0.1}{1000} \times 60 = 1.2$ g

Mass of acetic acid adsorbed/per gram

$= \frac{1.2}{0.6} = 2$ g

106. [63] M_{eq} of NH_3 = M_{eq} of used H_2SO_4

= M_{eq} of NaOH = N × V = 0.25 × 30 = 7.5

Millmoles of N = millimoles of NH_3 = 7.5

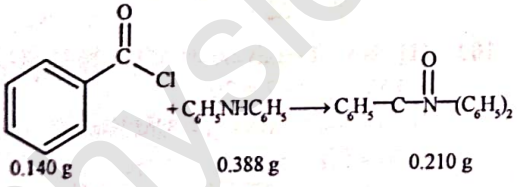
Mass of nitrogen = moles × molar mass

= 7.5 × 14 × 10 × 3 = 0.105 gm

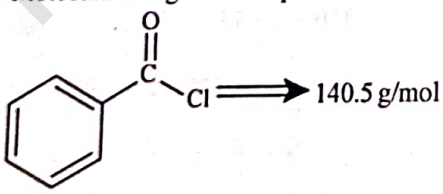
% of Nitrogen $= \frac{0.105}{0.166} \times 100\%$

= 63.25% ≈ 63%

107. [77] The reaction is

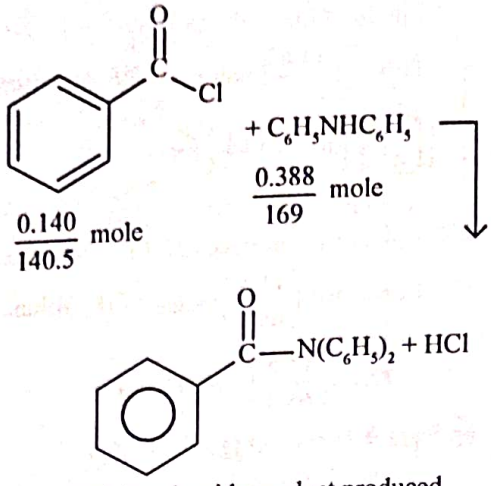


Molecular weight of compounds are:-



$C_6H_5NHC_6H_5 \Longrightarrow$ 169 g/mol

$C_6H_5-\overset{O}{\overset{\|}{C}}-N-(C_6H_5)_2 \Longrightarrow$ 273 g/mol



Weight of amide product produced

$\Rightarrow \frac{0.140}{140.5} \times 273 = 0.272$g

% Yield $= \frac{0.210}{0.272} \times 100 = 77.20\%$

108. [8] The general combustion reaction is:

$C_xH_y(g) + \left(x + \frac{y}{4}\right)O_2(g) \rightarrow xCO_2(g) + \frac{y}{2}H_2O(\ell)$

V 6V – –

– – 4V –

According to question,

Volume of CO_2 = 4 × VC_xH_y

Vx = 4V

x = 4

Volume of O_2 = 6 × VC_xH_y

$V\left(x + \frac{y}{4}\right) = 6V$

$\frac{y}{4} = 2; y = 8$

109. [16] $H_2C(OH)-CH_2-\overset{O}{\overset{\|}{C}}-H \xrightarrow{\Delta} C_3H_4O + H_2O$ (Acrolein)

Number of moles of acrolein $= \frac{7.8}{56}$ moles

According to the reaction, 1 mol of acrolein is dehydrated by 1 mol of 3-hydroxy propanal.

Hence, number of moles of 3-hydroxy propanol required for $\left(\frac{7.8}{56}\right)$ moles of acrolein dehydration $= \frac{7.8}{56}$ moles

Thus, Weight $= \frac{7.8 \times 74}{56} \times \frac{100}{64}$ g

= 16.10 g ≈ 16

110. [78] Moles of benzoic acid

$= \frac{\text{Weight}}{\text{Molar mass}} = \frac{6.1}{122} = 0.05$ moles

Theoretical moles of m-bromobenzoic acid = 0.05

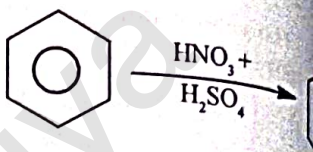
Observed moles of m-bromobe

$= \frac{7.8}{202} = 0.039$ moles

% yield

$= \frac{\text{Observed moles}}{\text{Theoretical moles}} = \frac{0.039}{0.05} \times 10$

111. [80]



According to above reaction, (3.

of benzene → $\left(\frac{3.9}{78}\right)$ mole of nitr

in 100% conversion.

Produced mole of nitrobenzene =

mole.

% yield $= \frac{\left(\frac{4.92}{123}\right) \times 100}{\frac{3.9}{78}} = \frac{4.92 \times 100 \times 78}{123 \times 3.9}$

112. [18] The combustion reaction is

$C_2H_6 + 7/2O_2 \longrightarrow 2CO_2 + 3H_2$

Mole of $C_2H_6 = \frac{\text{Weight}}{\text{Molar ma}}$

= 0.1 mol

($\because$ Molar mass of C_2H_6 = 30g/m

According to reaction,

1 mol of $C_2H_6 \longrightarrow$ 3 mol of H_2

0.1 mol of $C_2H_6 \longrightarrow$ 0.3 mol of

Hence, number of H_2O molecules

6.023×10^{23}

$= 18.06 \times 10^{22}$

So, x = 18 (Nearest Integer)

113. [19] $n_{C_3H_8} = \frac{100}{44} = 2.27$ mol

$n_{O_2} = \frac{1000}{32} = 31.25$ mol

$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) +$

At t = 0; 2.27 mol 31.25 mol 0

At t = ∞; 0 19.9mol 6.81mol

$x_{CO_2} = \frac{6.81}{19.9 + 6.81 + 9.08}$

$= 0.1902 = 19.02 \times 10^{-2}$

$\approx 19 \times 10^{-2}$

Hence, x = 19.

114. (*d*) First ionization enthalpy

= 496 kJ/mole

Second ionization enthalpy

= 4560 kJ/mol

According to the given inform

ionization enthalpy metal belo

group i.e. in the form monovale

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$MOH + HCl \longrightarrow MCl + H_2O$

1 mole 1 mole

$2MOH + H_2SO_4 \longrightarrow M_2SO_4 + H_2O$

1 mole 1/2 mole

115. (*b*) The reaction between Zn and dil. HCl is,

$Zn + 2\ dil.HCl \longrightarrow ZnCl_2 + H_2$

The reaction between Zn and aq. NaOH is,

$Zn + 2NaOH \longrightarrow Na_2ZnO_2 + H_2$

Mole of Zn

$= \frac{\text{Mole of dil. HCl}}{2} = \frac{\text{Mole of NaOH}}{2}$

$\frac{\text{volume of HCl}}{\text{volume of NaOH}} = \frac{1}{1}$

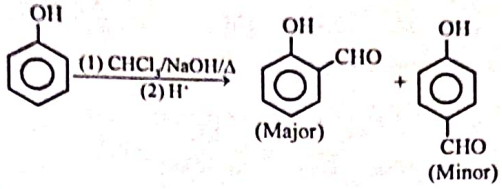
116. (*b*) $NH_2CONH_2 + 2NaOH \rightarrow 2NH_3 + Na_2CO_3$. 1 moles urea gives 2 moles of NH_3.

$NH_3 + HCl \rightarrow NH_4Cl$

$\therefore\ n_{Urea} = \frac{0.6}{60} = 0.01$ mole

$\therefore\ n_{NH_3} = 2 \times 0.01 = 0.02$ mole

117. [69] Reimer-Tiemann formylation reaction is:



Molecular formula of product is $C_7H_6O_2$

The mass percentage of carbon

$= \left(\frac{84}{122} \times 100\right) = 68.85\% = 69\%$

118. (*c*) $2C_{57}H_{110}O_6(s) + 163\,O_2(g) \rightarrow 114\,CO_2(g) + 110\,H_2O(l)$

$\frac{\text{Moles of } C_{57}H_{110}O_6}{2} = \frac{\text{Moles of } H_2O}{110}$

$\frac{445/890}{2} = \frac{\frac{\text{mass of } H_2O}{18}}{110}$

Mass of $H_2O = 495$ g

119. (*) Eq. of $(COOH)_2$ = Eq. of NaOH

$50 \times 0.5 \times 2 = 25 \times M \times 1$

Mass of NaOH in 50 mL $= \frac{50 \times 2}{1000} \times 40 = 4g$

None of the given options is correct.

120. (*c*) $N_2(g) + 3H_2 \rightarrow 2NH_3$

1 mole N_2 required 3 moles of H_2.

(*a*) $\frac{14}{28}$ $\frac{4}{2}$

121.....5 mole 2 mole

N_2 is L.R.

(*b*) $\frac{28}{28}$ $\frac{6}{2}$

1 mole 3 mole

No L.R.

(*c*) $\frac{56}{28}$ $\frac{10}{2}$

2 mol 5 mole

So, H_2 is L.R.

JEE-Advanced

1. (*a*) The molecular weight of oxalic acid dihydrate ($C_2H_2O_4 \cdot 2H_2O$) is 126 g/mol. It is a dibasic acid.

Its equivalent weight is $\frac{126}{2} = 63$.

Its normality is

$\frac{\text{weight}}{\text{equivalent weight}} \times \frac{1000}{\text{Volume in}} = \frac{6.3 \times 1000}{63 \times 250} = 0.4N$

But $N_1V_1 = N_2V_2$,

Hence, $0.1\ V_1 = 0.4 \times 10$

Thus, the volume of 0.1 N NaOH required to completely neutralize 10 mL of this solution is 40 mL.

2. (*d*) From given question we have Molarity (M) = 0.3M and we know that the relation between normality (N) and molarity(M). Then, we have

Normality (N) = Molarity × basicity (basicity of H_3PO_3 is 2)

So, $N = 0.3 \times 2 = 0.6N$

3. (*d*) Molarity depends on temperature.

$M \alpha \frac{1}{V} \alpha \frac{1}{T}$

V = Volume, T = Temperature

Normality = Molarity $\times n_{factor}$.

So, it depends upon temperature.

Formality

$\frac{\text{No. of gram formula masses dissolved}}{\text{Volumes (Litres)}}$

So, Formality also depends on temperature.

$V \propto T$

Molality is the one which depends upon the mass of the solute and the solvent.

The mass is independent of temperature.

Thus, molality is independent of temperature.

4. (*b*) Volume strength of hydrogen peroxide is defined as the term which is used to express the concentration of H_2O_2 with respect to the volumes of oxygen gas based on its decomposition to form water and oxygen.

Normality (N) = 1.5

Equivalent weight of H_2O_2 is 17

Strength of H_2O_2 = (Normality) × (Equivalent weight)

$= 1.5 \times 17 = 25.5$

$2H_2O_2 \rightarrow 2H_2O + O_2$

(2) (34 g) (22.4 L)

Since 68 grams of H_2O_2 produces 22.4 liters of oxygen at NTP,

Therefore, 25.5 grams of H_2O_2 will produce

= (22.4/68) 25.5 = 8.4 liter of oxygen

Thus, volume strength of given H_2O_2 solution is 8.4.

5. (*a*) According to molality (m) definition,

Molality is the number of moles of solute dissolved in 1000 grams of solvent. So 1 molal solution contains one mole of solute in 1000 grams of solvent.

Hence option (*a*) is correct.

6. (*d*) Chemical Reaction:

$3BaCl_2 + 2Na_3PO_4 \rightarrow Ba_3(PO_4)_2 + 6NaCl$

2 mol of $Na_3PO_4 \Rightarrow 3$ mol of $BaCl_2$

0.2 mol of $Na_3PO_4 \Rightarrow 0.3$ mol of $BaCl_2$

$\therefore$ Na_3PO_4 is the limiting reagent.

Thus, 2 mol of $Na_3PO_4 \Rightarrow 1$ mol of $Ba_3(PO_4)_2$

0.2 mol of $Na_3PO_4 \Rightarrow 0.1$ mol of $Ba_3(PO_4)_2$

7. (*a*) We know that, Atomic number $= n_p = n_e$

In case of carbon dioxide,

C has atomic number 6 so it has 6 electrons

oxygen has atomic no. 8, i.e., 16 electrons.

So total electrons present are in one mole of carbon dioxide (CO_2) = 16 + 6 = 22 electrons.

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8. **[2500]** No. of moles of unadsorbed

$CH_3CO_2H = \frac{40 \times 1}{1000} = 4 \times 10^{-2}$ mol

No. of moles of adsorbed

$CH_3CO_2H = \frac{100 \times 0.5}{1000} = 4 \times 10^{-2}$

$= 10^{-2}$ mol

Surface area occupied by 1 molecule of

$CH_3CO_2H = \frac{1.5 \times 10^2}{10^{-2} \times 6 \times 10^{23}} = \frac{150 \times 10^2 \times 10^{-23}}{6}$

$= 2500 \times 10^{-23}$ m²

∴ As per question, P = 2500

9. **[6.15]** Aluminium reacts with sulphuric acid to form aluminium sulphate and hydrogen.

$$\underset{\left(\frac{5.4}{27}=0.2\text{mol}\right)}{2Al} + \underset{\left(\frac{50\times5}{1000}=0.25\text{ mol}\right)}{3H_2SO_4} \rightarrow Al_2(SO_4)_3 + + 3H_2$$

H_2SO_4 is limiting reagent and moles of $H_2(g)$ produced = 0.25 mol

Using ideal gas equation,

$pV = nRT$

$\Rightarrow V = \frac{0.25 \times 0.082 \times 300}{1\text{atm}} \Rightarrow 6.15$ L

10. ***[2.98 or 2.99]***

$X_{area} = 0.05 = \frac{n}{n+50}$

$19n = 50$

$n = 2.6315$

V_{sol} ml $= \frac{(2.6315 \times 60 + 900)}{1.2} = 881.5789$

Molarity $= \frac{2.6315 \times 1000}{881.5789} = 2.9849$

Molarity = 2.98M

11. **[9]** Molecular weight of solute be = M_1

Molecular weight of solvent be M_2

Fraction of solute = 0.1

Let solution be litre

mass of solution = 2000 g

mass of solute = x mass of solvent = (2000 – x)g

Molarity $= \frac{x}{M_1}$/1 litre $= \frac{x}{M_1}$

Molality $= \frac{x}{M_1}/(2000 - x) \times 10^3$

$= \frac{1000x}{(2000-x)M_1}$

Molarity = Molality

$\frac{x}{M_1} = \frac{1000x}{(2000-x)M_1} = 2000 - x = 1000;$

x = 1000 gM

$\frac{\frac{1000}{M_1}}{\frac{1000}{M_1} + \frac{1000}{M_2}} \Rightarrow \frac{M_2}{M_1 + M_2} = 0.1$

$M_2 = 0.1M_1 + 0.1\ M_2$

$0.9\ M_2 = 0.1\ M_1$

$M_1/M_2 = 0.9/0.1 = 9$

12. **[8]** According to given question

$M_{(H_2X)} = 80\,\text{gmol}^{-1}$

$d_{solvent} = 0.4\,\text{gmol}^{-1}$

$M = 3.2 = \frac{n_B}{V_{solution}}$

$V_{solvent} = V_{solution} = 1000$ ml (given in question)

$W_{Solvent} = 0.4 \times 1000 = 400\text{g} = W_A$

3.2 moles of H_2X in 1000 ml of Solution

$n_B = 3.2$ moles

molality $= \frac{n_B}{W_A} \times 1000 = \frac{3.2 \times 1000}{400} = 8$ m

13. **[8]** Given data

100 g solution contains 29.2g HCl and molecular weight of HCl = 36.5 g/mol

Volume of solution $= \frac{\text{Mass}}{\text{density}} = \frac{100}{1.25} = 80$ ml

Molarity

$= \frac{\text{Mass of solute}}{\text{Mol.wt. of solute} \times \text{Volume (in ml)}} \times 1000$

$= \frac{29.2}{36.5 \times 80} \times 1000 = 10$ M

Let V ml of this HCl are used to prepare 200 ml of 0.4M HCl, then

milli-mole of conc. HCl = milli-mole of dil.HCl

(milli-mole does not change on dilution)

$V \times 10 = 200 \times 0.4 \Rightarrow V = 8$ ml

14. **[0.4]** The expression for the molality of the solution is

Molality (m)

$= \frac{\text{mass of salt}}{\text{molar mass of salt}} \times \frac{1}{\text{mass of water}}$

Substituting values in the above expression, we get kg

$m = \frac{3}{30} \times \frac{1}{250} \times 1000 = 0.4$m

The molality of the solution is 0.4 m.

15. **[6.023×10^{24}]** Number of electron in one molecule of H_2O is 2 + 8 = 10.

Density = 1 g/ml

∴ 18 ml means 18 g

Moles $= \frac{18}{18} = 1$

Electrons = $6.023 \times 10^{23} \times 10$ = 10^{24}

16. Given that for absorbed N_2 on sites,

$P(N_2) = 0.001$ atm, $V = 2.46$ cm³ = 2, T = 298

$n_{N_2} = \frac{PV}{RT} = \frac{0.001 \times 2.46 \times 10^{-3}}{0.0821 \times 298}$

Molecules of absorbed N_2 = 1.0 $6.023 \times 10^{23} = 6.023 \times 10^{16}$

Total surface sites available = N sites per cm² × Area = 6.023×10 = 6.023×10^{17}

Surface sites on which N_2 is abs = 20% × Available sites

$= \frac{20}{100} \times 6.023 \times 10^{17} = 12.046 \times$

∴ Number of sites absorbed per of $N_2 = \frac{12.046 \times 10^{16}}{6.023 \times 10^{16}} = 2$

17. The reaction is as follows:

$6CaO + P_4O_{10} \rightarrow 2Ca_3(PO_4)_2$

∵ 1 mole of P_4O_{10} requires 6 mo

∴ $\frac{852}{284}$ moles of P_4O_{10} require $\frac{6 \times 8}{284}$

CaO $= \frac{6 \times 852}{284} \times 56$gCaO

Therefore, mass of CaO required

18. Moles of CH_3COOH adsorbed = moles – Final moles.

$= 0.5 \times 100 \times 10^{-3} - 0.49 \times 10$
$= 0.05 - 0.049 = 0.001$ mole

No. of molecules of CH_3COOH absorbed $= 0.001 \times 6.02 \times 10^{23}$ $= 6.02 \times 10^{20}$

Surface area $= 3.01 \times 10^2$ m² (gi

Surface area of charcoal adsorb each molecule of CH_3COOH

$= \frac{3.01 \times 10^2}{6.02 \times 10^{20}} = 5 \times 10^{-19}$ m².

19. We know,

1 litre of water = 1 kg.

(Since, Density is 1000 kg/m³

Thus, 1000ml of water = 1 kg.

(Since, 1 litre = 1000ml)

Now, Mass of Water = 1 kg. = 10

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The molecular mass of the water molecules = 18 grams.

Using the formula,

$$\text{No.of moles} = \frac{\text{mass}}{\text{molar mass}}$$

$$= \frac{1000}{18} = 55.56 \text{ moles}$$

For the Molarity,

Using the Formula,

$$\text{Molarity} = \frac{\text{Number of moles}}{\text{volume in ml}} \times 1000 = \frac{55.56}{1000} \times 1000$$

$= 55.56M$

20. The balanced chemical reaction is :

$CuCO_3 + H_2SO_4 \rightarrow CuSO_4 + H_2O + CO_2$

Millimol of $CuCO_3 = (0.5 \times 1000)/123.5 = 4.048$

$\Rightarrow$ millimol of H_2SO_4 required = 4.048

$\because$ millimol = Molarity × Volume (in mL)

$\Rightarrow$ Vol = 4.048/0.50 = 8.1 mL

21. The reaction is as follows:

$KIO_3 + 5KI \rightarrow K_2O + 3I_2$

$$\text{Moles of } KIO_3 = \frac{0.1}{214}$$

$$\text{Moles of iodine liberated} = 3 \times \frac{0.1}{214}$$

$2Na_2S_2O_3 + I_2 \rightarrow 2NaI + Na_2S_4O_6$

$$\text{Moles of } Na_2S_2O_3 \text{ required} = 3 \times \frac{0.1}{214} \times 2$$

Molarity

$$= \frac{\text{Number of moles}}{\text{Volume}_{mL}} \times 1000$$

$$= 3 \times \frac{0.1}{214} \times 2 \times \frac{1}{45} \times 1000$$

$= 0.0623$ M

Therefore, molarity of the sodium thiosulphate solution is 0.0623 M

22. Normality is a concentration measurement expressed in gram equivalent weight per litre of fluid. The reactive capacity of a molecule is measured in gram equivalent weight the concentration of solution is determined by the solute's role in the reaction. The corresponding concentration of a solution is also known as normality.

Here given,

25ml H_2O_2 was reacted with excess of KI liberated I_2 consumed by 2 ml 0.3N $Na_2S_2O_3$ solution. The reaction involved in this liberation is

$2KI + H_2O_2 \rightarrow I_2 + 2KOH$

Let, Normality of 25ml H_2O_2 be xN

$\therefore$ From above titration

N_1 = Normality of H_2O_2

V_1 = Volume of H_2O_2

N_2 = Normality of $Na_2S_2O_3$ or I_2

V_2 = Volume of $Na_2S_2O_3$ or I_2

$\Rightarrow N_1V_1 = N_2V_2 \Rightarrow x \times 25 = 0.3 \times 20$

$$\Rightarrow x = \frac{0.3 \times 20}{25} = 0.24$$

$\therefore$ Normality of H_2O_2 solution = 0.24 N

Now, We know Volume strength = Normality × 5.6

Equivalent weight of H_2O_2 in terms of oxygen = 5.6L

$\Rightarrow$ Volume strength = $0.24 \times 5.6 = 1.344 gL^{-1}$

The volume strength of H_2O_2 solution is $1.344 gL^{-1}$

23. Moles of iodine = $\frac{0.508}{254}$ moles

Now, $M_1V_1 = M_2V_2$

$M_1 \rightarrow$ Molarity of H_2O_2 solution

$\therefore V_1 \rightarrow$ Volume of H_2O_2

$M_2 \rightarrow$ Molarity of iodine

$V_2 \rightarrow 1000ml \therefore M_1 \times 5 = \frac{0.508}{254} \times 1000$

$\therefore M_1 = 0.4M$

The reaction can be given as,

$H_2O_2 + 2I^- + 2H^+ \rightarrow 2H_2O + I_2$

$\therefore$ n-factor for $H_2O_2 = 2$

$\therefore$ Normality of $H_2O_2 = 2 \times 0.4 = 0.8N$

$\therefore$ Volume strength of $H_2O_2 = 0.8 \times 5.6 = 4.48$ volumes

24. We know that the relations

(i) Density = Mass/Volume

(ii) Molarity = Moles of solute/Volume of solution in L

(iii) Molality = Moles of solute/Mass of solvent in kg

(iv) Mole fraction of solute = Moles of solute/Total moles

The formula of Glauber's salt is $Na_2SO_4 \cdot 10H_2O$

Molecular mass of $Na_2SO_4 \cdot 10H_2O$

$= [2 \times 23 + 32.1 + 4 \times 16] + 10(1.01 \times 2 + 16) = 322.3 \text{ g mol}^{-1}$

Weight of the Glauber's salt taken

= 80.575gm

Out of 80.575 g of salt, weight of anhydrous Na_2SO_4 = 142.1/322.3 × 80.575 = 35.525 g

Number of moles of Na_2SO_4 per dm^3 of the solution = 35.525/142.1 = 0.25

Density of solution = $1077.2 kgm^{-3}$

$= 1077.2 \times 10^3 / 10^6 \text{ gmcm}^{-3} = 1.0772 \text{ g cm}^{-3}$

Total weight of sol = V × d = $1dm^3 \times d$

$= 1000 \text{ cm}^3 \times 1.0772 \text{ gcm}^{-3} = 1077.2$ g

Weight of water = 1077.2 – 35.525 = 1041.67 g

Molality of sol. (0.25/1041.67 g) × 1000 g = 0.2399 = 0.24m

Number of moles of water in the solution = 1041.67/18 = 57.87

Mole fraction of Na_2SO_4

= No. of moles of Na_2SO_4/ Total number of moles = 0.25/0.25 + 57.87

$= 0.0043 = 4.3 \times 10^{-3}$.

25. $3 Pb(NO_3)_2 + Cr_2(SO_4)_3 \rightarrow 3PbSO_4 + 2Cr_2(NO_3)_3$

No. of moles of $Pb(NO_3)_2 = 45 \times 10^{-3} \times 0.25 = 11.25 \times 10^{-3}$ mole

No. of moles of $Cr_2(SO_4)_3 = 25 \times 10^{-3} \times 0.1 = 2.5 \times 10^{-3}$ mole

Thus, $Cr_2(SO_4)_3$ has limiting amount. It shall be consumed fully and the number of moles of lead sulphate produced will be $= 3 \times 2.5 \times 10^{-3} = 7.5 \times 10^{-3}$ mole

No. of mole of lead nitrate left = $11.25 \times 10^{-3} - 7.5 \times 10^{-3} = 3.75 \times 10^{-3}$ mole

Total volume = (45.0 + 25.0) = 70 mL or 70×10^{-3} litre

$$\text{Molarity} = \frac{3.75 \times 10^{-3}}{70 \times 10^{-3}} = 0.0536M$$

No. of moles of $Cr(NO_3)_3$ formed = $2 \times 2.5 \times 10^{-3} = 5 \times 10^{-3}$ mole

$Pb(NO_3)_2$ and $Cr(NO_3)_3$ will be present in solution in ionic form.

Thus, $[Pb^{2+}] = 0.0536M$

$[Cr^{3+}] = 0.0714M$, $[NO_3^-]$

$= (2 \times 0.0536) + (3 \times 0.0714) = 0.3214M$.

26. 93% H_2SO_4 w/v means 93 g of H_2SO_4 is present in 100ml of solution.

Since volume is 1000ml, amount of H_2SO_4 is 930 g/ litre. Also density is given 1.84 g/ml

M = density × volume = 1.84 × 1000 = 1840 g

wt of solvent = 1840 – 930 = 910 g

$$\because \text{ molality} = \frac{\text{moles of solute}}{\text{weight of solvent in kg}}$$

$$\therefore \text{molality} = \frac{930}{98} \times \frac{1000}{910} = 10.43 \text{ mol/Kg}$$

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27. Given reactions are

(i) $2C_2H_6 + 2Br_2 \rightarrow 2C_2H_5Br + 2HBr$

(ii) $2C_2H_5Br + 2Na \rightarrow C_4H_{10} + 2NaBr$

Reactions (i) and (ii) reveal mole ratio

$C_2H_6 : C_2H_5Br : C_4H_{10} :: 2 : 2 : 1$

Now mole of butane formed = 55/58

Mole of C_2H_5Br actually required

$$= \frac{2 \times 55}{58} \times \frac{100}{85}$$

(∵ reaction efficiency is 85%)

Now similarly mole of C_2H_6 actually required

$$= \frac{2 \times 55}{58} \times \frac{100}{85} \times \frac{100}{90} = 2.479$$

(Since, this time effciency is 90 %)

Therefore, volume of C_2H_6 at NTP actually required

22.4 × 2.479 litre = 55.53 litre

28. (i) Mass of sugar = 34.2 g

No. of moles of sugar

$$= \frac{34.2}{\text{Molar mass}} = \frac{34.2}{342} = 0.1$$

Mass of water = (214.2 – 34.2) = 180 g

$$= \frac{180}{1000} kg$$

No. of moles of water $= \frac{180}{18} = 10$ mole

Molality

$$= \frac{\text{No. of moles of sugar}}{\text{Mass of water in kg}} = \frac{0.1}{180} \times 1000$$

= 0.555 m

Thus, the molality of sugar is 0.55 m

(ii) Total number of moles = 10.0 + 0.1 = 10.1

Mole fraction of sugar

$$= \frac{\text{No. of moles of sugar}}{\text{Total number of moles}} = \frac{0.1}{10.1} = 0.0099$$

Thus mole fraction of sugar in syrup is 0.0099.

29. (i)

Element	Percentage	Relative number of atoms	Simplest ratio
C	69.77	69.77/12 = 5.81	5
H	11.63	11.63/1 = 11.63	10
O	18.6	186/16 = 1.16	1

Thus, ratio of C,H and O in the compound is 5:10:1

∴ Empirical formula of compound = $C_5H_{10}O$

For molecular formula:

Empirical formula wt. = (12 × 5) + (10 × 1) + 16 = 86

Molecular wt. of compound = 86

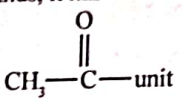
n = molecular wt./empirical formula wt. = 86/86 = 1

Molecular formula = (empirical formula) n = $C_5H_{10}O$

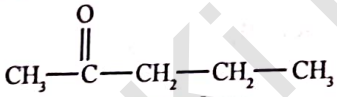
(ii) Compound forms bisulfite addition compound and thus, has carbonyl group, i.e., aldehyde or ketone.

(iii) It does not reduce Fehling solution and thus, it is not aldehyde but it is ketone.

(iv) It gives positive iodoform test and thus, it has

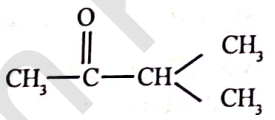


(v) Above facts reveals that compound is :



pentan-2-one

or



3-methyl butan-2-one

30. (i) Mass of 1000 mL of $Na_2S_2O_3$ solution = 1.25 × 1000 = 1250 g

Mass of $Na_2S_2O_3$ in 1000 mL of 3M solution

= 3 × Mol.mass of $Na_2S_2O_3$ = 3 × 158 = 474 g

Mass percentage of $Na_2S_2O_3$ in solution

$$= \frac{474}{1250} \times 100 = 37.92$$

(ii) No. of moles of $Na_2S_2O_3 = \frac{474}{158} = 3$

Mass of water = (1250 – 474) = 776 g

No. of moles of water $= \frac{776}{18} = 43.1$

Mole fraction of $Na_2S_2O_3$

$$= \frac{3}{43.1 + 3} = \frac{3}{46.1} = 0.065$$

(iii) No. of moles of Na^+ ions

= 2 × No.of moles of $Na_2S_2O_3$ = 2 × 3 = 6

Molality of Na^+ ions

$$= \frac{\text{No.of moles of } Na^+ \text{ ions}}{\text{Mass of water (in kg)}} = \frac{6}{776} \times 1000$$

= 7.73 m

No. of moles of $S_2O_3^{2-}$ ions = 3 mole of $Na_2S_2O_3$ = 3

Molality of $S_2O_3^{2-}$ ions

$$\frac{3}{776} \times 1000 = 3.86 m$$

31. Let the amount of sodium chlorid

The amount of potassium c (0.1180 – a)g.

$NaCl + AgNO_3 \rightarrow AgCl + Na$ ≡ $AgNO_3$)

The mass of AgCl formed =

$KCl + AgNO_3 \rightarrow AgCl + KNO$ (KCl

The mass of AgCl formed

$$= \frac{(0.1180 - a)}{74.5} \times 143.3$$

$$\therefore \left[\frac{a}{58.5} \times 143.5\right] + \left[\frac{(0.1180 - a)}{74.5} \times 143.5\right]$$

On solving, we get 'a' = 0.0338

$Na_2O \equiv 2NaCl$

$$\therefore \frac{W_{Na_2O}}{62} = \frac{0.0338}{2 \times 58.5} \Rightarrow W_{Na_2O} =$$

Percentage of Na_2O

$$= \frac{0.0179 \times 100}{0.500} = 3.58\%$$

Mass of KCl

= (0.1180 – a) = (0.1180 – 0.033

= 0.0842 g

$K_2O \equiv 2KCl$

$$\frac{W_{K_2O}}{94} = \frac{0.0842}{2 \times 74.5} \text{ or } W_{K_2O} = 0.0$$

Percentage of

$$K_2O = \frac{0.0531 \times 100}{0.500} = 10.62\%$$

32. Molar mass of mixture = 2 × 38.

No. of moles in 100 g of mixture

Let 'a' g of NO_2 is present in

Moles of N_2O_4 = 100 – a

Moles of NO_2 + Moles of N_2O_4 of mixture

$$\frac{a}{46} + \frac{100 - a}{92} = \frac{100}{76.6} \text{ "or" } a = 20$$

Moles of NO_2 in mixture $= \frac{20.10}{46}$

33. (*a*) The formula of silver carbonate i

Molecular weight of Ag_2CO_3 = 12 + 3 × 16 = 276g.

Reaction involved:

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$Ag_2CO_3(s) \xrightarrow{\Delta} 2Ag(s) + CO_2(g) + \frac{1}{2} O_2(g)$

Molecular weight of Ag = 2 × 108 = 216g

This means 276 g of Ag_2CO_3 yields 216 g of Ag

So, the amount of silver produced by 1 gram of $Ag_2CO_3 = \frac{216}{276}$

Similarly, the amount of silver produced by 2.76 grams of $Ag_2CO_3 = \frac{216}{276} \times 2.76 = 2.16g$

34. (*a*) The reactions of zinc with sulphuric acid and excess of sodium hydroxide separately are given below:

$Zn + 2NaOH \rightarrow Na_2ZnO_2 + H_2$

$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

In both the reactions, 1 mole of H_2 is evolved.

Hence, the ratio of volumes of hydrogen evolved is 1:1.

35. (*a*) If number of moles present are more that means more molecules are present.

Formula used -

$$\text{Number of moles} = \frac{\text{weight(g)}}{\text{molar mass}}$$

Number of molecules = number of moles × N_A

(*a*) 18g of $H_2O = 6.02 \times 10^{23}$ molecules of H_2O

∴ 36 g of $H_2O = 2 \times 6.02 \times 10^{23}$ molecules of H_2O

$= 12.04 \times 10^{23}$ molecules of H_2O

(*b*) 28 g of CO = 6.02×10^{23} molecules of CO

(*c*) 46 g of $C_2H_5OH = 6.02 \times 10^{23}$ molecules of C_2H_5OH

(*d*) 108 g of $N_2O_5 = 6.02 \times 10^{23}$ molecules of N_2O_5

∴ 54 g of $N_2O_5 = \frac{1}{2} \times 6.02 \times 10^{23}$ molecules of N_2O_5

$= 3.01 \times 10^{23}$ molecules of N_2O_5

∴ 36 g of water has highest number of molecules.

36. (*c*) The number of molecules of a gas is given by the expression, Number of molecules

$$= \frac{\text{Weight}}{\text{Molecular weight}} \times N_A.$$

Here, N_A is the Avogadro number.

Assume 1 g and 4 g of oxygen and nitrogen respectively.

Number of molecules of oxygen = $\frac{1}{32} \times N_A$

Number of molecules of nitrogen $= \frac{4}{28} \times N_A$

The ratio of the number of molecules of oxygen to nitrogen will be

$$= \frac{\frac{N_A}{32}}{4 \times \frac{N_A}{28}} = \frac{7}{32} = 7:32$$

37. (*b,c*)

(*a*) Compound 3 if compound is

$P_3Q_4 \Rightarrow \frac{3P}{4Q} = \frac{40}{60} = \frac{2}{3}$

$\frac{P}{Q} = \frac{8}{9}$

Compound 2

$P_3Q_5 \Rightarrow \frac{3P}{5Q} = \frac{44.4}{55.6}$

$\frac{P}{Q} = \frac{5}{3} 0.8$

$\frac{4}{3} = \frac{8}{6}$

Option '*a*' is wrong

(*b*) Compound 3

$P = \frac{40}{20} = 2 \quad 1.5 \quad 3$

formula = P_3Q_2

$Q = \frac{60}{45} = \frac{4}{3} \quad 1 \quad 2$

(*c*) Compound 2 $\Rightarrow \frac{P}{Q} = \frac{44.4}{55.6} = 0.8$

Compound 1 $\Rightarrow \frac{5P}{4Q} = \frac{5}{4} \Rightarrow \frac{P}{Q} = 1$

(*d*) Compound 1

$P = \frac{50}{70} = 1$

$Q = \frac{50}{35} = 2$

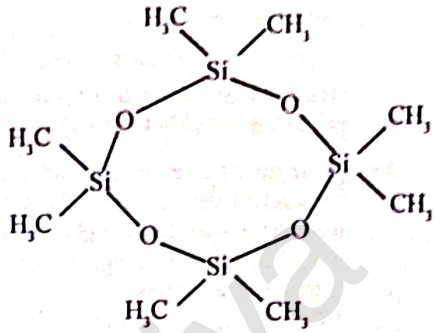
38. [222]

The reaction that occurs is:

$4(CH_3)_2SiCl_2 + 4H_2O \xrightarrow{75\%} (CH_3)_8Si_4O_4 + 8HCl$ (X)

w = 516 g

$n = \frac{516}{129} = 4$ moles



Weight = 296 g (molecular mass)

% yield = 75

The weight of X(in g) = $296 \times \frac{75}{100} = 222g$

39. [2.385] The reaction that occurs is:

$P_4 + 3NaOH + 3H_2O \rightarrow PH_3 + 3NaH_2PO_2$

Moles of phosphorous = 1.24/ 124 = 0.01mol

Since 1 mol of P forms 1 mol of PH_3, 0.01 mol of P will form 0.01 mol of PH_3

$2PH_3 + 3CuSO_4 \rightarrow Cu_3P_2 + 3H_2SO_4$

No. of moles of $CuSO_4$ required to consume 2 mol of phosphine (Q) = 3 mole $CuSO_4$

So, no. of moles of $CuSO_4$ required to consume 0.01 mol of phosphine

$(Q) = (\frac{3}{2} \times 0.01)$ mol

Molar mass of $CuSO_4$ = 159 g/mol

Mass of $CuSO_4 = (\frac{3}{2} \times 0.01) \times 159 = 2.385$ g

40. [6.47] Reaction involved

$PbS + O_2 \rightarrow Pb + SO_2$

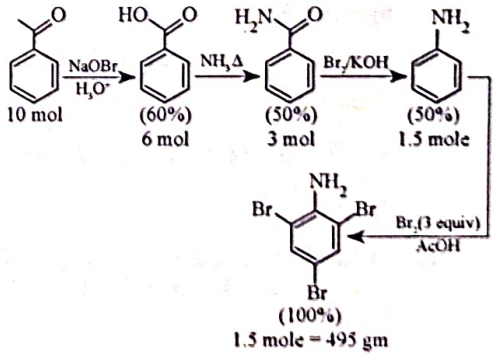
No. of moles of Pb = No. of moles of O_2

$= \frac{1000}{32}$ mol

∴ Mass of Pb = $\frac{1000}{32} \times 207$ g

$= \frac{207 \text{ Kg}}{32} = 6.47$ Kg

41. [495]



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The product D formed in the reaction is 2,4,6-tribromo aniline and 1.5 moles of this will be formed from 10 moles of acetophenone.

Molar mass of product will be = 330g

Hence, amount 2,4,6-tribromo aniline produced is 330 × 1.5 = 495 g

42. **[3]** If the calculation is an addition or a substraction, the rule is as follows: limit the reported answer to the rightmost column that all numbers have significant figures in common. For example, if you were to add 1.2 and 4.71, we note that the first number stops its significant figures in the tenths column, while the second number stops its significant figures in the hundredths column. We therefore limit our answer to the tenths column.

1.2
+
4.41
5.61
↑ limit final answer to the tenths column : 5.6

We drop the last digit, that is 1 because it is not significant to the final answer.

The dropping of positions in sums and differences brings up the topic of rounding. Although there are several conventions, in this text we will adopt the following rule: the final answer should be rounded up if the first dropped digit is 5 or greater, and rounded down if the first dropped digit is less than 5.

77.2
+
10.46
87.66
↑ limit final answer to the tenths column : 87.7

We have 25.2,25.25 and 25.0 ml.

$$\text{Average} = \frac{25.2+25.25+25.0}{3} = \frac{75.45}{3}$$

$$= 25.15 = 25.2 \text{ ml}$$

When dividing, the final answer will have the same amount of significant figures as the number with the least significant numbers.

As a result, the important number is three.

Therefore, the number of significant figures is 3.

43. **[7/3]** Let oxidation state of Copper be x.

$YBa_2Cu_3^{x}O_7$

$3 + (2 \times 2) + 3x + (-2 \times 7) = 0$

$\Rightarrow x = \frac{7}{3}$

44. **[4.14 g]** Molar mass of $CuSO_4 \cdot 5H_2O$ = 63.5 + 32 + 4 × 16 + 5 × 18 = 249.5 g/mol

Thus, 249.5 g of $CuSO_4 \cdot 5H_2O$ contains avogadro's number of molecules.

The weight of 1×10^{22} molecules of $CuSO_4 \cdot 5H_2O$ is $\frac{249.5}{6.023 \times 10^{23}} \times 10^{22} = 4.14g$

45. (C-12 isotopes) According to modern atomic mass unit, one atomic mass unit (amu) is defined as one-twelfth of mass of an atom of C-12. That is, equal to $\frac{1}{12}$ of the mass of an atom of carbon-12.

46. Specific volume = $\frac{\text{Volume}}{\text{Mass}}$

$$\text{Mass of a virus} = \frac{\pi r^2 h}{\text{Specific Valume}}$$

$$= \frac{3.14 \times (75 \times 10^{-8})^2 \times 5000 \times 10^{-8}}{0.75}$$

$$\text{Molar mass} = \frac{3.14 \times (7.5 \times 10^{-8})^2 \times 5000 \times 10^{-8} \times 6.02 \times 10^{23}}{0.75}$$

$= 7.08 \times 10^7$ g/mol

$$\text{Mass} = \frac{3.14 \times (75 \times 10^{-2})^2 \times 5000 \times 10^{-8}}{0.5}$$

Molar mass = Mass × N

$$= \frac{3.14 \times (75 \times 10^{-2})^2 \times 5000 \times 10^{-8}}{0.5} \times$$

$6.023 \times 10^{23} = 7.092 \times 10^7$ g/mol

47. Fe_3O_4 is an equimolar mixture of Fe_2O_3 and FeO. Thus, the sample contains Fe_2O_3, FeO and impurities. The amount of iodine liberated depends on the amount of Fe_2O_3 and the entire iron is converted into Fe^{2+}.

$Fe_3O_4 + 2KI + H_2SO_4 \rightarrow 3FeO + H_2O + K_2SO_4 + I_2$

5 × 11.0 mL of 0.5M$Na_2S_2O_3$ ≡ 55.0 mL of 0.5M

= $Na_2S_2O_3$ soln.

≡ 55.0 mL of 0.5 M I^{2-} soln.

≡ 55.0 mL of 0.5 M Fe_2O_3 soln.

= 27.5×10^{-3} equivalent Fe_3O_4 soln.

= 13.75×10^{-3} moles Fe_2O_3

2 × 12.8 mL of 0.25M $KMnO_4$ soln

≡ 25.6 mL of 0.25 M $KMnO_4$ soln.

≡ 25.6 mL of 0.25 M FeO soln.

= 32.0×10^{-3} equivalent FeO

= 32.0×10^{-3} moles FeO

Moles of FeO in Fe_3O_4 = 0.032 – 0.0275 = 0.0045

Mass of Fe_3O_4 = 0.0045 × 232 = 1.044g

Moles of Fe_2O_3 existing separately

= 0.01375 – 0.0045 = 0.00925

Mass = 0.00925 × 160 = 1.48

$$\%Fe_3O_4 = \frac{1.044}{3} \times 100 = 34.8\%$$

$$Fe_2O_3 = \frac{1.48}{3} \times 100 = 49.33\%$$

The percentage of Fe_2O_3 is 49.
Fe_3O_4 is 34.8% in the original

48. Let volume of CO, CH_4 and H_e and z respectively.

Given, ∴ x + y + z = 20...(i)

The reactions are:

$CO + \frac{1}{2}O_2 \rightarrow CO_2$

$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$

∴ Volume of CO_2 formed (x+y) =

By Eqs. (i) and (ii), z = 6

Also, an initial volume of the m
final volume after sparking = 13

$x + y + z + VO_2 - [x + y + z + V$

∴ V_{O_2} used = 13 or, $\frac{x}{2} + 2y =$

∴ x = 10, y = 4

∴ x + 4y = 26

$$\%CO = \frac{10}{20} \times 100 = 50\%$$

$$\% \text{ of } CH_4 = \frac{4}{20} \times 100 = 20\%$$

$$\% \text{ of He} = \frac{6}{20} \times 100 = 30\%$$

49. A is binary salt of univalent m
converts S to sulphate.Hence A c
oxygen. Since, A is a binary salt th
be

MO_2 (superoxide) with O_2^- anion

1 mole of S corresponds to 1 m
sulphate.

Let M be the molecular mass of m
A.

$(MO_2)_{(M+32)} + S_{32} \rightarrow M_2SO_{4(2M+}$

$$\frac{2M+96}{32} = \frac{1.743}{0.321}$$

M + 32 and (2M + 96) is molar m
compound MO_2 and M_2SO_4

Hence, M = 38.87 = 39

Thus, binary compound

A is KO_2, B is K_2SO_4, C is K
$Al_2(SO_4)_3 \cdot 24H_2O$ (alum).

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50. Number of millimoles of KIO_3 in 30ml of solution = (Molarity) × (volume in ml)

$= \frac{1}{10} \times 30 = 3$

Equation:

$KIO_3 + 2KI + 6HCl \rightarrow 3ICl + 3KCl + 3H_2O$

According to the equation of the reaction given 1mole of KIO_3 is equivalent to 2 moles of KI

No. of millimoles of KI in 20ml of stock solution = 2 × 3 = 6

∴ No. of millimoles of KI in 50ml of solution

$= 6 \times \frac{50}{20} = 15$

∴ No. of KIO_3 in 50ml of solution

$\frac{1}{10} \times 50 = 5$

No. of millimoles of KI used with 50ml of KIO_3 solution = 2 × 5 = 10

No. of millimoles of KI used with $AgNO_3$ = 15 – 10 = 5

$AgNO_3 + KI \rightarrow AgI + KNO_3$

1 mole of $AgNO_3$ react 1 mole of KI. Therefore, number of millimoles of $AgNO_3$ is equal to 5 .

Weight of $AgNO_3 = 5 \times 10^{-3} \times 170g = 0.85g$

of $AgNO_3 = \frac{0.85 \times 100}{1.0} = 85.0\%$

51. Let the mass of $Pb(NO_3)_2$ be x g.

The reaction is given below:

$Pb(NO_3)_2 \rightarrow PbO + 2NO_2\uparrow + \frac{1}{2}O_2\uparrow$

For 331 g $Pb(NO_3)_2$, loss in weight = 108 g

For a $Pb(NO_3)_2$, loss in weight $= \frac{108x}{331}$ g

Let the mass of $NaNO_3$ be y g.

$NaNO_3 \rightarrow NaNO_2 + \frac{1}{2}O_2\uparrow$

For 85 g $NaNO_3$, loss in weight = 16 g

For y g $NaNO_3$, loss in weight $= \frac{16y}{85}$ g

Loss in weight $= \frac{5}{100} \times 28g$ (Given)

$\therefore \frac{108x}{331} + \frac{16y}{85} = \frac{5}{100} \times 28$ ...(i)

Also, x + y = 5 ...(ii)

On solving equations (i) and (ii), we get x = 3.32 g and y = 1.68 g ⇒ 1.7 g.

52. Let there be x mL CO in the mixture, hence, there will be: (1000 – x) mL CO_2. The reaction of CO_2 with red hot charcoal may be given as:

$CO_2 + C \rightarrow 2CO$

Total volume of the gas becomes

= x + 2(1000 – x)

x + 2000 – 2x = 1600 mL, x = 400 mL

∴ Volume of CO = 400 mL and 0.4 L volume of CO_2 = 600 mL.= 0.6 L.

53. Let the formula of the hydrocarbon be C_xH_y. It combustion can be shown by the following equation:

$C_xH_y + \left(x + \frac{y}{4}\right)O_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$

1 vol $\left(x + \frac{y}{4}\right)$ mL x vol

5 mL $5\left(x + \frac{y}{4}\right)$ mL 5x vol

Volume of carbon dioxide produced

= (25 – 15) = 10 mL

5x = 10

or x = 2

Volume of oxygen used = (30 – 15) = 15 mL

$5\left[x + \frac{y}{4}\right] = 15$ or $x + \frac{y}{4} = \frac{15}{5} = 3$

or $2 + \frac{y}{4} = 3$

or $\frac{y}{4} = 3 - 2 = 1$

or y = 4

Thus, the molecular formula of the hydrocarbon = C_2H_4

54. The atomic masses of most elements are fractional because they exist as a mixture of isotopes of different masses.

Most elements occur as a mixture of isotopes of different masses. Hence the atomic weight is average of atomic masses of all the naturally occurring isotopes.

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2 Structure of Atom

JEE-Main

Sub-Atomic Particles and Atomic Models

1. Given below are two statements: one is labelled as assertion and the other is labelled as reason.

   Assertion (A): Loss of electron from hydrogen atom results in nucleus of ~1.5×10^{-3} pm size.

   Reason (R): Proton (H^+) always exists in combined form.

   In the light of the above statements, choose the most appropriate answer from the options given below: **[6 April, 2023 (Shift-I)]**

   (*a*) Both (A) and (R) are correct and (R) is the correct explanation of (A)

   (*b*) (A) is correct but (R) is not correct

   (*c*) (A) is not correct but (R) is correct

   (*d*) Both (A) and (R) are correct but (R) is NOT the correct explanation of (A).

2. Electrons in a cathode ray tube have been emitted with a velocity of $1000\ ms^{-1}$. The number of following statements which is/are true about the emitted radiation is _____.

   Given: $h = 6 \times 10^{-34}$ Js, $m_e = 9 \times 10^{-31}$ kg. **[1 Feb, 2023 (Shift-I)]**

   (*a*) The deBroglie wavelength of the electron emitted is 666.67nm

   (*b*) The characteristic of electrons emitted depend upon the material of the electrodes of the cathode ray tube

   (*c*) The cathode rays start from cathode and move towards anode

   (*d*) The nature of the emitted electrons depends on the nature of the gas present in cathode ray tube

3. Consider an imaginary ion $^{48}_{22}X^{3-}$. The nucleus contains 'a'% more neutrons than the number of electrons in the ion. The value of 'a' is_____. [nearest integer] **[26 July, 2022 (Shift-II)]**

4. If the Thompson model of the atom was correct, then the result of Rutherford's gold foil experiment would have been: **[27 July, 2021 (Shift-II)]**

   (*a*) All α – particles get bounced back by 180°

   (*b*) α – particles are deflected over a wide range of angles

   (*c*) All of α – particles pass through the gold foil without decrease in speed

   (*d*) α – particles pass through the gold foil deflected by small angles and with reduced speed

5. Amongst the following statements, that which was not proposed by Dalton was **[7 Jan, 2020 (Shift-I)]**

   (*a*) Matter consists of invisible atoms

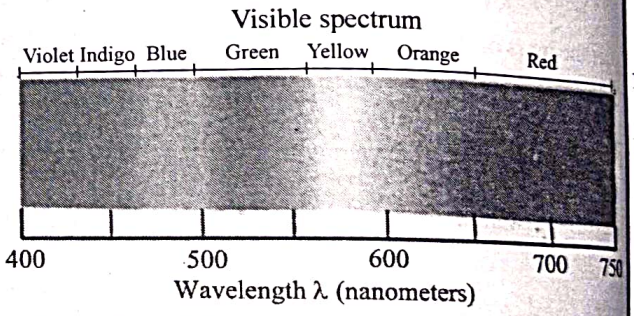
   (*b*) When gases combine or reproduced in a chemical r they do so in a simple ratio by volume provided all ga at the same temperature & pressure

   (*c*) Chemical reactions involve reorganisation of atoms are neither created nor destroyed in a chemical react

   (*d*) All the atoms of a given element have identical pro including identical mass Atoms of different elements in mass

Developments Leading to the Bohr's Model of Atom

6.



Which of the following statements are correct, if the thr frequency of caesium is 5.16×10^{14} Hz?

A. When Cs is placed inside a vacuum chamber with an am connected to it and yellow light is focused on Cs, the am shows the presence of current.

B. When the brightness of the yellow light is dimmed, th of the current in the ammeter is reduced.

C. When a red light is used instead of the yellow light, the produced is higher with respect to the yellow light.

D. When a blue light is used, the ammeter shows the for of current.

E. When a white light is used, the ammeter shows forma current.

Choose the correct answer from the options given below: **[07 April, 2025 (S**

(*a*) A, D and E Only (*b*) B , C and D Only

(*c*) A, C, D and E Only (*d*) A, B, D and E Only

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7. Heat treatment of muscular pain involves radiation of wavelength of about 900 nm. Which spectral line of H atom is suitable for this?
Given: Rydberg constant $R_H = 10^5$ cm^{-1}, $h = 6.6 \times 10^{-34}$ Js, $c = 3 \times 10^8$ m/s) **[23 Jan, 2025 (Shift-I)]**
(a) Lyman series, $\infty \rightarrow 1$ (b) Balmer series, $\infty \rightarrow 2$
(c) Paschen series, $5 \rightarrow 3$ (d) Paschen series, $\infty \rightarrow 3$

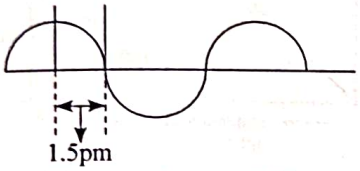
8. The ionization energy of sodium in kJ mol^{-1}. If electromagnetic radiation of wavelength 242 nm is just sufficient to ionize sodium atom is_____. **[31 Jan, 2024 (Shift-I)]**

9. Match **List-I** with **List-II**.

	List-I Alkali Metal		List-II Emission Wavelength (in nm)
A.	Li	I	589.2
B.	Na	II.	455.5
C.	Rb	III.	670.8
D.	Cs	IV.	780.0

Choose the **correct** answer from the options given below: **[06 April, 2024 (Shift-II)]**
(a) (A)-(I), (B)-(IV), (C)-(III), (D)-(II)
(b) (A)-(III), (B)-(I), (C)-(IV), (D)-(II)
(c) (A)-(IV), (B)-(II), (C)-(I), (D)-(III)
(d) (A)-(II), (B)-(IV), (C)-(III), (D)-(I)

10. A hypothetical electromagnetic wave is show below.



The frequency of the wave is $x \times 10^{19}$ Hz.
x = _____ (nearest integer). **[08 April, 2024 (Shift-I)]**

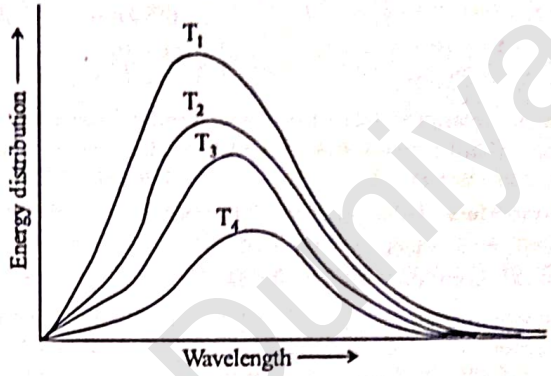
11. Wavenumber for a radiation having 5800 Å wavelength is $x \times 10$ cm^{-1}. The value of x is _____. **[08 April, 2024 (Shift-II)]**

12. Given below are two statements: one is labelled as **Assertion (A)** and the other is labelled as **Reason (R)**:
Assertion (A): In the photoelectric effect, the electrons are ejected from the metal surface as soon as the beam of light of frequency greater than threshold frequency strikes the surface.
Reason (R): When the photon of any energy strikes an electron in the atom, transfer of energy from the photon to the electron takes place. **[11 April, 2023 (Shift-I)]**
In the light of the above statements, choose the most appropriate answer from the options given below:
(a) Both (A) and (R) are correct but (R) is NOT the correct explanation of (A)
(b) (A) is correct but (R) is not correct
(c) Both (A) and (R) are correct and (R) is the correct explanation of (A)
(d) (A) is not correct but (R) is correct

13. The wavelength of an electron of kinetic energy 4.50×10^{-29} J is___ $\times 10^{-5}$m. (Nearest integer)
Given : mass of electron is 9×10^{-31} kg, $h = 6.6 \times 10^{-34}$ J s **[6 April, 2023 (Shift-I)]**

14. The number of incorrect statement/s about the black body from the following is _____. **[10 April, 2023 (Shift-I)]**
(a) Emit or absorb energy in the form of electromagnetic radiation
(b) Frequency distribution of the emitted radiation depends on temperature
(c) At a given temperature, intensity vs frequency curve passes through a maximum value
(d) The maximum of the intensity vs frequency curve is at a higher frequency at higher temperature compared to that at lower temperature

15. Following figure shows spectrum of an ideal black body at four different temperatures. The number of correct statement/s from the following is _____. **[24 Jan, 2023 (Shift-II)]**



(a) $T_4 > T_3 > T_2 > T_1$
(b) The black body consists of particles performing simple harmonic motion
(c) The peak of the spectrum shifts to shorter wavelength as temperature increases
(d) $\frac{T_1}{V_1} = \frac{T_2}{V_2} = \frac{T_3}{V_3} \neq$ constant
(e) The given spectrum could be explained using quantisation of energy

16. The number of following statement/s which is/are incorrect is **[8 April, 2023 (Shift-I)]**
(a) Line emission spectra are used to study the electronic structure
(b) The emission spectra of atoms in the gas phase show accontinuous spread of wavelength from red to violet
(c) An absorption spectrum is like the photographic negative of an emission spectrum
(d) The element helium was discovered in the sun by spectroscopic method

17. Values of work function (W_0) for a few metals are given below:

Metal	Li	Na	K	Mg	Cu	Ag
W_0/eV	2.42	2.3	2.25	3.7	4.8	4.3

The number of metals which will show photoelectric effect when light of wavelength 400 nm falls on it is _____
Given: $h = 6.6 \times 10^{-34}$ J s
$c = 3 \times 10^8$ ms^{-1}; $e = 1.6 \times 10^{-19}$ C **[12 April, 2023 (Shift-I)]**

18. The energy of one mole of photons of radiation of frequency 2×10^{12} Hz in J mol^{-1} is _____.
(Nearest integer)
(Given: $h = 6.626 \times 10^{-34}$ Js
$N_A = 6.022 \times 10^{23}$ mol^{-1}) **[30 Jan, 2023 (Shift-I)]**

19. The energy of one mole of photons of radiation of wavelength 300 nm is
(Given: $h = 6.63 \times 10^{34}$ Js, $N_A = 6.02 \times 10^{23}$ mol^{-1}, $c = 3 \times 10^8$ ms^{-1}) **[24 June, 2022 (Shift-II)]**
(a) 235 kJ mol^{-1} (b) 325 kJ mol^{-1}
(c) 399 kJ mol^{-1} (d) 435 kJ mol^{-1}

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20. If the work function of a metal is 6.63×10^{-19}J, the maximum wavelength of the photon required to remove a photoelectron from the metal is _____ nm. (Nearest integer)
[Given $h = 6.63 \times 10^{-34}$Js, and $c = 3 \times 10^{8}$ms^{-1}]
[28 June, 2022 (Shift-I)]

21. The minimum energy that must be possessed by photons in order to produce the photoelectric effect with platinum metal is:
[Given: The threshold frequency of platinum is 1.3×10^{15} s^{-1} and $h = 6.6 \times 10^{-34}$ J s.] **[25 June, 2022 (Shift-II)]**
(a) 3.21×10^{-34} J (b) 6.24×10^{-16} J
(c) 8.58×10^{-19} J (d) 9.76×10^{-20} J

22. The wavelength of electrons accelerated from rest through a potential difference of 40 kV is $x \times 10^{-12}$ m. The value of x is _____. (Nearest Integer) **[20 July, 2021 (Shift-II)]**
Given: Mass of electron = 9.1×10^{-31} kg
Charge on an electron = 1.6×10^{-19} C
Planck's constant = 6.63×10^{-34} Js

23. A metal surface is exposed to 500 nm radiation. The threshold frequency of the metal for photoelectric current is 4.3×10^{14} Hz. The velocity of ejected electron is _____ $\times 10^{5}$ ms^{-1}. (Nearest integer)
[Use: $h = 6.63 \times 10^{-34}$ Js, $m_e = 9.0 \times 10^{-31}$ kg]
[26 Aug, 2021 (Shift-II)]

24. A 50 watt bulb emits monochromatic red light of wavelength of 795 nm. The number of photons emitted per second by the bulb is $x \times 10^{20}$. The value of x is _____.
[Given: $h = 6.63 \times 10^{-34}$ Js and $c = 3.0 \times 10^{8}$ ms^{-1}]
[1 Sept, 2021 (Shift-II)]

25. A proton and a Li^{3+} nucleus are accelerated by the same potential. If λ_{Li} and λ_p denote the de Broglie wavelengths of Li^{3+} and proton respectively, then the value of $\frac{\lambda_{Li}}{\lambda_P}$ is $x \times 10^{-1}$. The value of x is _____(Rounded off to the nearest integer) [Mass of Li^{3+} = 8.3 mass of proton]
[24 Feb, 2021 (Shift-I)]

26. Electromagnetic radiation of wavelength 663 nm is just sufficient to ionise the atom of metal A. The ionization energy of metal A in kJ mol^{-1} is_____(Rounded-off to the nearest integer)
[$h = 6.63 \times 10^{-34}$ Js, $c = 3.00 \times 10^{8}$ ms^{-1}, $N_A = 6.02 \times 10^{23}$ mol^{-1}]
[25 Feb, 2021 (Shift-II)]

27. A source of monochromatic radiation of wavelength 400 nm provides 1000 J of energy in 10 seconds. When this radiation falls on the surface of sodium, $x \times 10^{20}$ electrons are ejected per second. Assume that wavelength 400 nm is sufficient for ejection of electron from the surface of sodium metal. The value of x is _____ (Nearest integer) ($h = 6.626 \times 10^{-34}$Js)
[25 July, 2021 (Shift-I)]

28. The number of photons emitted by a monochromatic (single frequency) infrared range finder of power 1 mW and wavelength of 1000 nm, in 0.1 second is $x \times 10^{13}$. The value of x is _____. (Nearest integer)
($h = 6.63 \times 10^{-34}$ Js, $c = 3.00 \times 10^{8}$ ms^{-1}) **[27 July, 2021 (Shift-II)]**

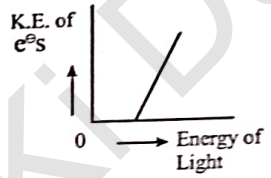
29. When light of wavelength 248 nm falls on a metal of threshold energy 3.0eV, the de-Broglie wavelength of emitted electrons is _____ Å. (Round off to the nearest Integer).
[Use : $\sqrt{3} = 1.73$, $h = 6.63 \times 10^{-34}$ Js
$m_e = 9.1 \times 10^{-31}$ kg : $c = 3.0 \times 10^{8}$ ms; 1eV = 1.6×10^{-19} J]
[16 March, 2021 (Shift-I)]

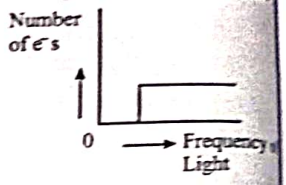
30. The work function of sodium metal is 4.41×10^{-19} J. If photons of wavelength 300 nm are incident on the metal, the kinetic energy of the ejected electrons will be($h = 6.63 \times 10^{-34}$ J s; $c = 3 \times 10^{8}$ ms^{-1}) _____ $\times 10^{-21}$ J. **[2 Sept, 2021 (Shift-I)]**

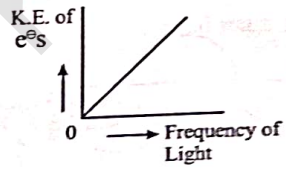
31. The region in the electromagnetic spectrum where the Balmer series lines appear is: **[4 Sept, 2020 (Shift-I)]**
(a) Ultraviolet (b) Visible
(c) Infrared (d) Microwave

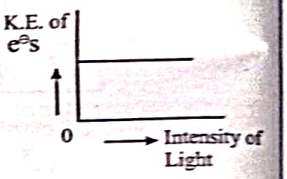
32. If P is the momentum of the fastest electron ejected from a metal surface after the irradiation of light having wavelenght λ, then 1.5p momentum of the photoelectron, the wavelength of the light should be:
(Assume kinetic energy of ejected photoelectron to be very less in comparison to work function). **[8 April, 2019 (Shift-I)]**
(a) $\frac{1}{2}\lambda$ (b) $\frac{3}{4}\lambda$ (c) $\frac{2}{3}\lambda$ (d) $\frac{4}{9}\lambda$

33. Which of the graphs shown below does not represent the relationship between incident light and the electron ejected from metal surface? **[10 Jan, 2019 (Shift-I)]**

(a)


(b)


(c)


(d)


34. What is the work function of the metal if the light of wavelength 4000 Å generates photoelectrons of velocity 6×10^{5} ms^{-1} from metal? **[12 Jan, 2019 (Shift-I)]**
(Mass of electron = 9×10^{-31} kg
Velocity of light = 3×10^{8} ms^{-1}
Planck's constant = 6.626×10^{-34} Js
Charge of electron = 1.6×10^{-19} JeV^{-1})
(a) 0.9 eV (b) 3.1 eV
(c) 2.1 eV (d) 4.0 eV

Bohr's Model for Hydrogen Atom

35. The energy of an electron in first Bohr orbit of H -atom is -13.6 eV. The magnitude of energy value of electron in the first excited state of Be^{3+} is _____ eV. (nearest integer value)
[08 April, 2025 (Shift-I)]

36. Which of the following postulate of Bohr's model of hydrogen atom is not in agreement with quantum mechanical model of an atom
[03 April, 2025 (Shift-I)]
(a) An atom in a stationary state does not emit electromagnetic radiation as long as it stays in the same state.
(b) An atom can take only certain distinct energies E_1, E_2, etc. These allowed states of constant energy are called stationary states of atom.
(c) When an electron makes a transition from a higher energy stationary state to a lower energy stationary state, then it emits a photon of light.
(d) The electron in a H atom's stationary state moves in a circle around the nucleus.

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37. According to Bohr's model of hydrogen atom, which of the following statement is **incorrect**? **[02 April, 2025 (Shift-I)]**

(*a*) Radius of 3rd orbit is nine times larger than that of 1st orbit.

(*b*) Radius of 8th orbit is four times larger than that of 4th orbit.

(*c*) Radius of 6th orbit is three times larger than that of 4th orbit.

(*d*) Radius of 4th orbit is four times larger than that of 2nd orbit.

38. Radius of the first excited state of Helium ion is given as: $a^0 \rightarrow$ radius of first stationary state of hydrogen atom.

[22 Jan, 2025 (Shift-I)]

(*a*) $r = 2a_0$ (*b*) $r = 4a_0$ (*c*) $r = \frac{a_0}{2}$ (*d*) $r = \frac{a_0}{4}$

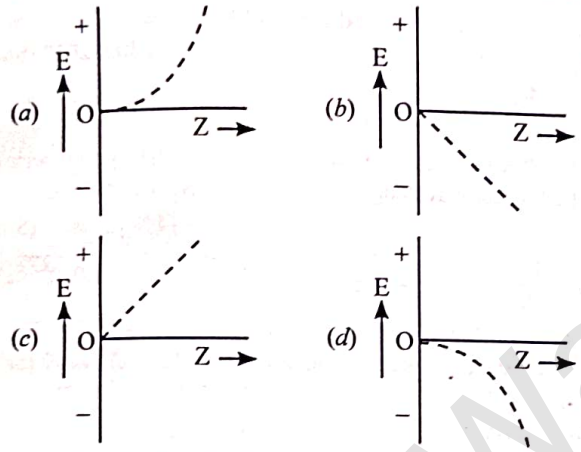
39. If a_0 is denoted as the Bohr radius of hydrogen atom, then what is the de-Broglie wavelength (λ) of the electron present in the second orbit of hydrogen atom? [n : any integer]

[29 Jan, 2025 (Shift-I)]

(*a*) $\frac{2a_0}{n\pi}$ (*b*) $\frac{4\pi a_0}{n}$ (*c*) $\frac{8\pi a_0}{n}$ (*d*) $\frac{4n}{\pi a_0}$

40. For hydrogen like species, which of the following graphs provides the most appropriate representation of E vs Z plot for a constant n?

[E: Energy of the stationary state, Z: atomic number, n = principal quantum number] **[29 Jan, 2025 (Shift-II)]**



41. Match List-I with List-II

List-I (Spectral Series for Hydrogen)		List-II (Spectral Region/ Higher Energy State)	
A.	Lyman	I.	Infrared region
B.	Balmer	II.	UV region
C.	Paschen	III.	Infrared region
D.	Pfund	IV.	Visible region

Choose the correct answer from the options given below:

[29 Jan, 2024 (Shift-II)]

(*a*) A-II, B-III, C-I, D-IV (*b*) A-I, B-III, C-II, D-IV

(*c*) A-II, B-IV, C-III, D-I (*d*) A-I, B-II, C-III, D-IV

42. Number of spectral lines obtained in He^+ spectra. When an electron makes transition from fifth excited state to first excited state will be _____. **[30 Jan, 2024 (Shift-II)]**

43. The de-Broglie's wavelength of an electron in the 4th orbit is _____ πa_0. (a_0 = Bohr's radius) **[04 April, 2024 (Shift-I)]**

44. The value of Rydberg constant (R_H) is 2.18×10^{-18} J. The velocity of electron having mass 9.1×10^{-31} kg in Bohr's first orbit of hydrogen atom = _____ $\times 10^5$ ms^{-1} (nearest integer)

[05 April, 2024 (Shift-I)]

45. For hydrogen atom, energy of an electron in first excited state is –3.4eV. K.E. of the same electron of hydrogen atom is xeV. Value of x is _____ $\times 10^{-1}$ eV (Nearest integer).

[06 April, 2024 (Shift-II)]

46. The shortest wavelength of hydrogen atom in Lyman series is λ. The longest wavelength in Balmer series of He^+ is

[29 Jan, 2023 (Shift-I)]

(*a*) $\frac{5}{9\lambda}$ (*b*) $\frac{9\lambda}{5}$ (*c*) $\frac{36\lambda}{5}$ (*d*) $\frac{5\lambda}{9}$

47. The radius of the 2nd orbit of Li^{2+} is x. The expected radius of the 3rd orbit of Be^{3+} is **[25 Jan, 2023 (Shift-I)]**

(*a*) $\frac{9}{4}x$ (*b*) $\frac{4}{9}x$ (*c*) $\frac{27}{16}x$ (*d*) $\frac{16}{27}x$

48. Given below are two statements:

Statement-I: According to Bohr's model of hydrogen atom, the angular momentum of an electron in a given stationary state is quantised.

Statement-II: The concept of electron in Bohr's orbit, violates the Heisenberg uncertainty principle. In the light of the above statements, choose the most appropriate answer from the options given below: **[15 April, 2023 (Shift-I)]**

(*a*) Both Statement-I and Statement-II are correct

(*b*) Statement-I is correct but Statement-II is incorrect

(*c*) Statement-I is incorrect but Statement-II is correct

(*d*) Both Statement-I and Statement-II are incorrect

49. The energy of an electron in the first Bohr orbit of hydrogen atom is -2.18×10^{-18} J. Its energy in the third Bohr orbit is

[13 April, 2023 (Shift-I)]

(*a*) $\frac{1}{27}$ of this value (*b*) One third of this value

(*c*) Three times of this value (*d*) $\frac{1}{9}$ of this value

50. If the radius of the first orbit of hydrogen atom a_0, then de Broglie's wavelength of electron in 3rd orbit is **[6 April, 2023 (Shift-II)]**

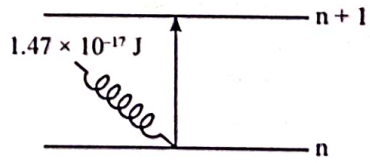
(*a*) $\frac{\pi a_0}{6}$ (*b*) $\frac{\pi a_0}{3}$ (*c*) $6\pi a_0$ (*d*) $3\pi a_0$

51. If wavelength of the first line of the Paschen series of hydrogen atom is 720 nm, then the wavelength of the second line of this series is _____ nm. (Nearest integer) **[24 Jan, 2023 (Shift-I)]**

52. Assume that the radius of the first Bohr orbit of hydrogen atom is 0.6 Å. The radius of the third Bohr orbit of He^+ is _____ picometer. (Nearest Integer) **[29 Jan, 2023 (Shift-II)]**

53. The electron in the nth orbit of Li^{2+} is excited to (n + 1) orbit using the radiation of energy 1.47×10^{-17} J (as shown in the diagram). The value of n is _____ .

Given $R_H = 2.18 \times 10^{-18}$ J **[10 April, 2023 (Shift-II)]**



54. If the radius of the 3rd Bohr's orbit of hydrogen atom is r_3 and the radius of 4th Bohr's orbit is r_4. Then: **[26 June, 2022 (Shift-I)]**

(*a*) $r_4 = \frac{9}{16}r_3$ (*b*) $r_4 = \frac{16}{9}r_3$ (*c*) $r_4 = \frac{3}{4}r_3$ (*d*) $r_4 = \frac{4}{3}r_3$

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55. When the excited electron of a H atom from n = 5 drops to the ground state, the maximum number of emission lines observed are _____. [25 July, 2022 (Shift-II)]

56. If the wavelength for an electron emitted from H-atom is 3.3×10^{-6} m, then energy absorbed by the electron in its ground state compared to minimum energy required for its escape from the atom, is _____ times. (Nearest integer)
[Given: $h = 6.626 \times 10^{-34}$ Js
Mass of electron = 9.1×10^{-31} kg] [28 July, 2022 (Shift-II)]

57. The longest wavelength of light that can be used for the ionization of lithium atom (Li) in its ground state is $x \times 10^{-8}$ m. The value of x is_____. (Nearest Integer) [25 June, 2022 (Shift-I)]

58. Given below are two statements:
Statement-I: Bohr's theory accounts for the stability and line spectrum of Li^+ ion.
Statement-II: Bohr's theory was unable to explain the splitting of spectral lines in the presence of a magnetic field.
In the light of the above statements, choose the most appropriate answer from the options given below: [18 March, 2021 (Shift-II)]
(a) Both statement-I and statement-II are true
(b) Statement-I is true but statement-II is false
(c) Both statement-I and statement-II are false
(d) Statement-I is false but statement-II is true

59. Given below are two statements.
Statement-I: According to Bohr's model of an atom, qualitatively the magnitude of velocity of electron increases with decrease in positive charges on the nucleus as there is no strong hold on the electron by the nucleus.
Statement-II: According to Bohr's model of an atom, qualitatively the magnitude of velocity of electron increases with decrease in principal quantum number. [26 Aug, 2021 (Shift-I)]
In the light of the above statements, choose the most appropriate answer from the options given below:
(a) Statement-I is false but Statement-II is true
(b) Statement-I is true but Statement-II is false
(c) Both Statement-I and Statement-II are true
(d) Both Statement-I and Statement-II are false

60. According to Bohr's atomic theory: [24 Feb, 2021 (Shift-I)]
(A) Kinetic energy of electron is $\propto \frac{Z^2}{n^2}$
(B) The product of velocity (v) of electron and principal quantum number (n) 'vn' $\propto Z^2$
(C) Frequency of revolution of electron in an orbit is $\propto \frac{Z^3}{n^3}$
(D) Coulombic force of attraction on the electron is $\propto \frac{Z^3}{n^4}$
Choose the most appropriate answer from the options given below:
(a) (A) and (D) only (b) (A) only
(c) (A), (C) and (D) only (d) (C) only

61. The kinetic energy of an electron in the second Bohr orbit of a hydrogen atom is equal to $\frac{h^2}{xma_0^2}$. The value of 10x is _____. (a_0 is radius of Bohr's orbit) (Nearest integer)
[Given : $\pi = 3.14$]
[27 Aug, 2021 (Shift-I)]

62. Given below are two statements:
Statement-I: Rutherford's gold foil experiment ca... line spectrum of hydrogen atom.
Statement-II: Bohr's model of hydrogen atom ... Heisenberg's uncertainty principle.
In the light of the above statements, choose the most ... answer from the options given below: [27 July, 2021 ...
(a) Statement-I is true but Statement-II is false
(b) Both Statement-I and Statement-II are false
(c) Both Statement-I and Statement-II are true
(d) Statement-I is false but Statement-II is true

63. For the Balmer series in the spectrum of H atom, $\bar{v} = R_H \left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right]$ ... the correct statements among (I) to (IV) are: [8 Jan, 2020 ...
(I) As wavelength decreases, the lines in the series co...
(II) The integer n_1 is equal to n_2
(III) The lines of longest wavelength corresponds to $n_2 = 3$
(IV) The ionization energy of hydrogen can be calcula... wave number of these lines
(a) (II), (III), (IV) (b) (I), (III), (IV)
(c) (I), (II), (III) (d) (I), (II), (IV)

64. The radius of the second Bohr orbit, in terms of the Bohr ... a_0, in Li^{2+} is [8 Jan, 2020 (Sh...
(a) $\frac{4a_0}{3}$ (b) $\frac{2a_0}{9}$ (c) $\frac{2a_0}{3}$ (d) $\frac{4a_0}{9}$

65. The shortest wavelength of H atom in the Lyman series ... The longest wavelength in the Balmer Series of He^+ is: [4 Sept, 2020 (Sh...
(a) $\frac{5\lambda_1}{9}$ (b) $\frac{36\lambda_1}{5}$ (c) $\frac{9\lambda_1}{5}$ (d) $\frac{27\lambda_1}{5}$

66. The ground state energy of hydrogen atom is –13.6 eV. The ... of second excited state of He^+ ion eV is: [10 Jan, 2019 (Sh...
(a) –54.4 (b) –3.4
(c) –6.04 (d) –27.2

67. The ratio of the shortest wavelength of two spectral se... hydrogen spectrum is found to be about 9. The spectral ser... [10 April, 2019 (Sh...
(a) Paschen and Pfund (b) Lyman and Paschen
(c) Brackett and Pfund (d) Balmer and Brackett

68. Which one of the following about an electron occupy... s-orbital in a hydrogen atom is incorrect? (The Bohr ... represented by a_0) [9 April, 2019 (Sh...
(a) The electron can be found at a distance $2a_0$ from the ...
(b) The probability density of finding the electron is ma... at the nucleus
(c) The magnitude of potential energy is double that of its ... energy on an average
(d) The total energy of the electron is maximum when it ... distance a_0 from the nucleus

69. For emission line of atomic hydrogen from $n_i = 8$ to $n_f = n$, ... of wave number ($\bar{v}$) against $\left(\frac{1}{n^2}\right)$ will be (The Rydberg co... R_H is in wave number unit): [9 Jan, 2019 (Sh...
(a) Linear with intercept - R_H (b) Non linear
(c) Linear with slope R_H (d) Linear with slope - R_H

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70. For any given series of spectral lines of atomic hydrogen, let $\Delta\bar{\nu} = \bar{\nu}_{max} - \bar{\nu}_{min}$ be the difference in maximum and minimum frequencies in cm^{-1}. The ratio $\Delta\bar{\nu}_{Lyman} / \Delta\bar{\nu}_{Balmer}$ is:

[9 April, 2019 (Shift-I)]

(*a*) 27 : 5 (*b*) 4 : 1 (*c*) 5 : 4 (*d*) 9 : 4

71. Heat treatment of muscular pain involves radiation of wavelength of about 900 nm. Which spectral line of H–atom is suitable for this purpose?

[$R_H = 1 \times 10^5\ cm^{-1}$, $h = 6.6 \times 10^{-34}$ Js, $c = 3 \times 10^8\ ms^{-1}$]

[11 Jan, 2019 (Shift-I)]

(*a*) Paschen, $\infty \rightarrow 3$ (*b*) Paschen, $5 \rightarrow 3$

(*c*) Balmer, $\infty \rightarrow 2$ (*d*) Lyman, $\infty \rightarrow 1$

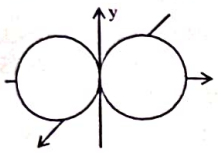
72. If the de-Brogile wavelength of the electron in n^{th} Bohr orbit in a hydrogenic atom is equal to $1.5\pi a_0$ (a_0 is Bohr radius), then the value of n/z is: **[12 Jan, 2019 (Shift-II)]**

(*a*) 0.40 (*b*) 1.50 (*c*) 1.0 (*d*) 0.75

Towards Quantum Mechanical Model of the Atom

73. Which of the following statements are **true**?

(A) The subsidiary quantum number *l* describes the shape of the orbital occupied by the electron.

(B) 

x is the boundary surface diagram of the $2p_x$ orbital.

(C) The + and – signs in the wave function of the $2p_x$ orbital refer to charge.

(D) The wave function of $2p_x$ orbital is zero everywhere in the *xy* plane. **[02 April, 2025 (Shift-II)]**

(*a*) (B) and (D) only (*b*) (A), (B) and (C) only

(*c*) (C) and (D) only (*d*) (A) and (B) only

74. Given below are two statements:

Statement (I): It is impossible to specify simultaneously with arbitrary precision, both the linear momentum and the position of a particle.

Statement (II): If the uncertainty in the measurement of position and uncertainty in measurement of momentum are equal for an electron, then the uncertainty in the measurement of velocity is $\geq \sqrt{\frac{h}{\pi}} \times \frac{1}{2m}$

In the light of the above statements, choose the **correct** answer from the options given below: **[29 Jan, 2025 (Shift-II)]**

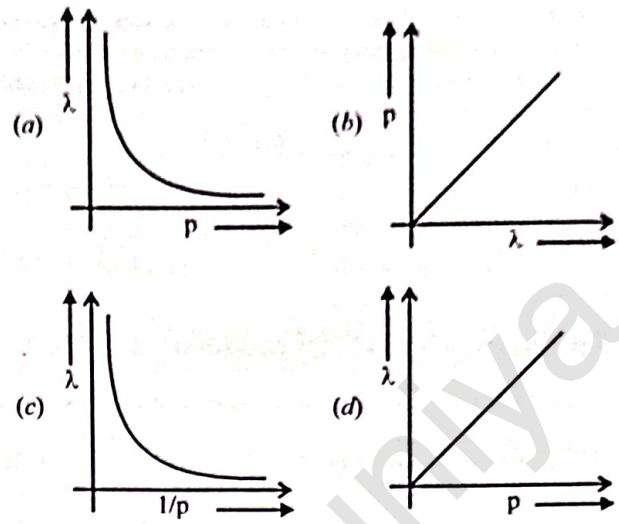
(*a*) Both Statement I and Statement II are true

(*b*) Statement I is false but Statement II is true

(*c*) Statement I is true but Statement II is false

(*d*) Both Statement I and Statement II are false

75. According to the wave-particle duality of matter by de-Broglie, which of the following graph plot presents most appropriate relationship between wavelength of electron (λ) and momentum of electron (p)? **[01 Feb, 2024 (Shift-I)]**



76. Frequency of the de-Broglie wave of electron in Bohr's first orbit of hydrogen atom is _____ × 10^{13} Hz (nearest integer).

[Given: R_H (Rydberg constant) = 2.18×10^{-18} J. *h* (Plank's constant) = 6.6×10^{-34} J.s.] **[06 April, 2024 (Shift-I)]**

77. Based on Heisenberg's uncertainty principle, the uncertainty in the velocity of the electron to be found within an atomic nucleus of diameter 10^{-15} m is _____ × $10^9\ ms^{-1}$ (nearest integer)

[Given: mass of electron = 9.1×10^{-31} kg, Plank's constant (h) = 6.626×10^{-34} Js]

(Value of $\pi = 3.14$) **[09 April, 2024 (Shift-II)]**

78. The wave function (Ψ) of 2s is given by

$$\psi_{2s} = \frac{1}{2\sqrt{2\pi}}\left(\frac{1}{a_0}\right)^{1/2}\left(2 - \frac{r}{a_0}\right)e^{-r/2a_0}$$

At $r = r_0$, radial node is formed. Thus, r_0 in terms of a_0

[30 Jan, 2023 (Shift-II)]

(*a*) $r_0 = a_0$ (*b*) $r_0 = 4a_0$ (*c*) $r_0 = \frac{a_0}{2}$ (*d*) $r_0 = 2a_0$

79. If the uncertainty in velocity and position of a minute particle in space are: $2.4 \times 10^{-26}(ms^{-1})$ and 10^{-7}(m) respectively. The mass of the particle in g is _____. (nearest integer)

(Given: $h = 6.626 \times 10^{-34}$Js) **[27 June, 2022 (Shift-I)]**

80. The wavelength of an electron and a neutron will become equal when the velocity of the electron is x times the velocity of neutron. The value of x is _____. (Nearest Integer)

(Mass of electron is 9.1×10^{-31} kg and mass of neutron is 1.6×10^{-27} kg)

[26 July, 2022 (Shift-I)]

81. The minimum uncertainty in the speed of an electron in an one dimensional region of length $2a_0$ (Where a_0 = Bohr radius 52.9 pm) is _____ km s^{-1}.

(Given: Mass of electron = 9.1×10^{-31} kg, Planck's constant, $h = 6.63 \times 10^{-34}$Js) **[29 July, 2022 (Shift-I)]**

82. An accelerated electron has speed of $5 \times 10^6\ ms^{-1}$ with an uncertainty of 0.02%. The uncertainty in finding its location while in motion is $x \times 10^{-9}$ m. The value of x is _____. (Nearest integer)

[Use mass of electron = 9.1×10^{-31} kg, $h = 6.63 \times 10^{-34}$ Js, $\pi = 3.14$] **[25 July, 2021 (Shift-II)]**

83. The de Broglie wavelength of an electron in the 4th Bohr orbit is: **[9 Jan, 2020 (Shift-I)]**

(*a*) $6\pi a_0$ (*b*) $4\pi a_0$ (*c*) $2\pi a_0$ (*d*) $8\pi a_0$

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The de-Broglie wavelength (λ) associated with a photoelectron varies with the frequency (ν) of the incident radiation as [ν_0 is threshold frequency]: **[11 Jan, 2019 (Shift-II)]**

(a) $\lambda \propto \frac{1}{(\nu-\nu_0)}$ (b) $\lambda \propto \frac{1}{(\nu-\nu_0)^{\frac{1}{4}}}$

(c) $\lambda \propto \frac{1}{(\nu-\nu_0)^{\frac{3}{2}}}$ (d) $\lambda \propto \frac{1}{(\nu-\nu_0)^{\frac{1}{2}}}$

Quantum Mechanical Model of the Atom

85. Correct statements for an element with atomic number 9 are

A. There can be 5 electrons for which $m_s = +\frac{1}{2}$ and 4 electrons for which $m_s = -\frac{1}{2}$

B. There is only one electron in p_z orbital

C. The last electron goes to orbital with n = 2 and $l = 1$

D. The sum of angular nodes of all the atomic orbitals is 1 .

Choose the correct answer from the options given below: **[08 April, 2025 (Shift-II)]**

(a) C and D Only (b) A and C Only

(c) A, C and D Only (d) A and B Only

86. Consider the ground state of chromium atom (Z=24). How many electrons are with Azimuthal quantum number l=1 and l=2 respectively? **[04 April, 2025 (Shift-II)]**

(a) 12 and 4 (b) 16 and 4

(c) 12 and 5 (d) 16 and 5

87. Which one of the following about an electron occupying the 1 s orbital in a hydrogen atom is incorrect? (Bohr's radius is represented by a_0) **[04 April, 2025 (Shift-I)]**

(a) The probability density of finding the electron is maximum at the nucleus

(b) The electron can be found at a distance $2a_0$ from the nucleus

(c) The 1s orbital is spherically symmetrical

(d) The total energy of the electron is maximum when it is at a distance a_0 from the nucleus

88. For electrons in '2s' and '2p' orbitals, the orbital angular momentum values, respectively are : **[03 April, 2025 (Shift-II)]**

(a) $\sqrt{2}\frac{h}{2\pi}$ and 0 (b) $\frac{h}{2\pi}$ and $\sqrt{2}\frac{h}{2\pi}$

(c) 0 and $\sqrt{6}\frac{h}{2\pi}$ (d) 0 and $\sqrt{2}\frac{h}{2\pi}$

89. Given below are two statements: **[22 Jan, 2025 (Shift-II)]**

Statement I: A spectral line will be observed for a $2p_x \rightarrow 2p_y$ transition.

Statement II: $2p_x$ and $2p_y$ are degenerate orbitals.

In the light of the above statements, choose the correct answer from the options given below:

(a) Both statement I and statement II are true.

(b) Statement I is true but statement II is false.

(c) Both statement I and statement II are false.

(d) Statement I is false but statement II is true.

90. Given below are two statements: **[23 Jan, 2025 (Shift-I)]**

Statement (I): For a given shell, the total number of allowed orbitals is given by n^2.

Statement (II): For any subshell, the spatial orientation of orbitals is given by $-l$ to $+l$ values including zero.

In the light of the above statements, choose the **correct** answer from the options given below:

(a) Both Statement I and Statement II are false

(b) Both Statement I and Statement II are true

(c) Statement I is false but Statement II is true

(d) Statement I is true but Statement II is false

91. In a multielectron atom, which of the following orbitals described by three quantum numbers will have same energy in absence of electric and magnatic fields?

A. $n = 1, l = 0, m_l = 0$ B. $n = 2, l = 0, m_l = 0$

C. $n = 2, l = 1, m_l = 1$ D. $n = 3, l = 2, m_l = 1$

E. $n = 3, l = 2, m_l = 0$

Choose the ***correct*** answer from the options given below; **[28 Jan, 2025 (Shift-I)]**

(a) A and B Only (b) D and E Only

(c) B and C Only (d) C and D Only

92. Which of the following is/are not correct with respect to energy of atomic orbitals of hydrogen atom?

(A) $1s < 2p < 3d < 4s$ (B) $1s < 2s = 2p < 3s = 3p$

(C) $1s < 2s < 2p < 3s < 3p$ (D) $1s < 2s < 4s < 3d$

Choose the correct answer from the options given below: **[28 Jan, 2025 (Shift-II)]**

(a) (A) and (C) only (b) (A) and (B) only

(c) (B) and (D) only (d) (C) and (D) only

93. For hydrogen atom, the orbital/s with lowest energy is/are :

(A) 4s (B) $3p_x$ (C) $3d_{x^2-y^2}$

(D) $3d_{z^2}$ (E) $4p_z$

Choose the **correct** answer from the options given below : **[24 Jan, 2025 (Shift-II)]**

(a) (B) only (b) (A) only

(c) (A) and (E) only (d) (B), (C) and (D) only

94. The number of electrons present in all the completely filled subshells having $n = 4$ and $s = +\frac{1}{2}$ is _____.

(Where n = principal quantum number and s = spin quantum number) **[27 Jan, 2024 (Shift-I)]**

95. The correct set of four quantum numbers for the valence electron of rubidium atom (Z = 37) is: **[29 Jan, 2024 (Shift-I)]**

(a) $5,0,0+\frac{1}{2}$ (b) $5,0,1+\frac{1}{2}$

(c) $5,1,0+\frac{1}{2}$ (d) $5,1,1+\frac{1}{2}$

96. Given below are two statements:

Statement-I: The orbitals having same energy are called degenerate orbitals.

Statement-II: In hydrogen atom, 3p and 3d orbitals are degenerate orbitals.

In the light of the above statements, choose the **most appropriate** answer from the options given **[30 Jan, 2024 (Shift-I)]**

(a) Statement-I is true but Statement-II is false

(b) Both Statement-I and Statement-II are true.

(c) Both Statement-I and Statement-II are false

(d) Statement-I is false but Statement-II is true

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97. The four quantum numbers for the electron in the outer most orbital of potassium (atomic no. 19) are [31 Jan, 2024 (Shift-II)]

(a) $n = 4, l = 2, m = -1, s = +\frac{1}{2}$

(b) $n = 4, l = 0, m = 0, s = +\frac{1}{2}$

(c) $n = 3, l = 0, m = 1, s = +\frac{1}{2}$

(d) $n = 2, l = 0, m = 0, s = +\frac{1}{2}$

98. The number of radial node/s for 3p orbital is: [01 Feb, 2024 (Shift-II)]

(a) 1 (b) 4 (c) 2 (d) 3

99. The maximum number of orbitals which can be identified with $n = 4$ and $m_l = 0$ is_____ [04 April, 2024 (Shift-II)]

100. In an atom, total number of electrons having quantum numbers $n = 4, |m_l| = 1$ and $m_s = -1/2$ is [05 April, 2024 (Shift-II)]

101. Compare the energies of following sets of quantum numbers for multielectron system. [09 April, 2024 (Shift-I)]

(A) $n = 4, l = 1$ (B) $n = 4, l = 2$

(C) $n = 3, l = 1$ (D) $n = 3, l = 2$

(E) $n = 4, l = 0$

Choose the correct answer from the options given below:

(a) (B) > (A) > (C) > (E) > (D)

(b) (E) > (C) < (D) < (A) < (B)

(c) (E) > (C) > (A) > (D) > (B)

(d) (C) < (E) < (D) < (A) < (B)

102. Maximum number of electrons that can be accommodated in shell with $n = 4$ are: [30 Jan, 2023 (Shift-II)]

(a) 16 (b) 32 (c) 50 (d) 72

103. Arrange the following orbitals in decreasing order of energy? [31 Jan, 2023 (Shift-II)]

(A) $n = 3, l = 0, m = 0$ (B) $n = 4, l = 0, m = 0$

(C) $n = 3, l = 1, m = 0$ (D) $n = 3, l = 2, m = 1$

The correct option for the order is:

(a) B > D > C > A (b) D > B > C > A

(c) A > C > B > D (d) D > B > A > C

104. The number of given orbitals which have electron density along the axis is _____

$p_x, p_y, p_z, d_{xy}, d_{yz}, d_{xz}, d_{z^2}, d_{x^2-y^2}$ [25 Jan, 2023 (Shift-II)]

105. The number of atomic orbitals from the following having 5 radial nodes is _____.

7s, 7p, 6s, 8p, 8d [8 April, 2023 (Shift-II)]

106. The number of correct statements from the following_____. [11 April, 2023 (Shift-II)]

(a) For 1s orbital, the probability density is maximum at the nucleus.

(b) For 2s orbital, the probability density first increases to maximum and then decreases sharply to zero.

(c) Boundary surface diagrams of the orbitals encloses a region of 100% probability of finding the electron.

(d) p and d-orbitals have 1 and 2 angular nodes respectively.

(e) Probability density of p-orbital is zero at the nucleus.

107. The orbital angular momentum of an electron in 3s orbital is $\frac{sh}{2\pi}$. The value of s is _____. [13 April, 2023 (Shift-II)]

108. The number of radial and angular nodes in 4d orbital are, respectively [26 June, 2022 (Shift-II)]

(a) 1 and 2 (b) 3 and 2

(c) 1 and 0 (d) 2 and 1

109. The correct decreasing order of energy for the orbitals having following set of quantum numbers: [27 July, 2022 (Shift-II)]

(A) $n=3, l = 0, m = 0$ (B) $n=4, l = 0, m = 0$

(C) $n=3, l = 1, m = 0$ (D) $n=3, l = 2, m = 1$

(a) (D) > (B) > (C) > (A) (b) (B) > (D) > (C) > (A)

(c) (C) > (B) > (D) > (A) (d) (B) > (C) > (D) > (A)

110. Identify the incorrect statement from the following. [28 July, 2022 (Shift-I)]

(a) A circular path around the nucleus in which an electron moves is proposed as Bohr's orbit.

(b) An orbital is the one electron wave function (ψ) in an atom.

(c) The existence of Bohr's orbits is supported by hydrogen spectrum

(d) Atomic orbital is characterised by the quantum numbers n and l only.

111. Given below are two statements: One is labelled as Assertion (A) and the other is labelled as Reason (R):

Assertion (A): Zero orbital overlap is an out of phase overlap.

Reason (R): It results due to different orientation/direction of approach of orbitals. [28 July, 2022 (Shift-II)]

In the light of the above statements, choose the correct answer from the options given below

(a) Both A and R are true and R is the correct explanation of A

(b) Both A are R are true but R is NOT the correct explanation of A

(c) A is true but R is false

(d) A is false but R is true

112. Consider the following pairs of electrons [24 June, 2022 (Shift-I)]

(A) (a) $n = 3, l = 1, ml = 1, m_s = +\frac{1}{2}$

(b) $n = 3, l = 2, ml = 1, m_s = +\frac{1}{2}$

(B) (a) $n = 3, l = 2, ml = -2, m_s = -\frac{1}{2}$

(b) $n = 3, l = 2, ml = -1, m_s = -\frac{1}{2}$

(C) (a) $n = 4, l = 2, ml = 2, m_s = +\frac{1}{2}$

(b) $n = 3, l = 2, ml = -2, m_s = +\frac{1}{2}$

The pairs of electrons present in degenerate orbitals is/are:

(a) Only (A) (b) Only (B)

(c) Only (C) (d) (B) and (C)

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113. Consider the following statements: **[28 June, 2022 (Shift-II)]**

(A) The principal quantum number 'n' is a positive integer with values of 'n' = 1, 2, 3, ...

(B) The azimuthal quantum number 'l' for a given 'n' (principal quantum number) can have values as 'l' = 0, 1, 2, ... n

(C) Magnetic orbital quantum number 'm_l' for a particular 'l' (azimuthal quantum number) has $(2l + 1)$values.

(D) $\pm 1/2$ are the two possible orientations of electron spin.

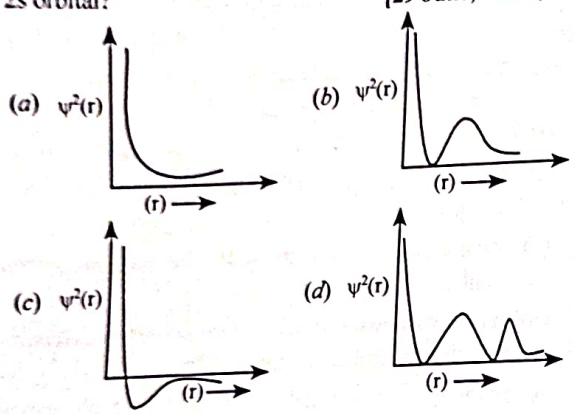
(E) For $l = 5$,there will be a total of 9 orbital

Which of the above statements are correct?

(a) (A), (B) and (C) (b) (A), (C), (D) and (E)

(c) (A), (C) and (D) (d) (A), (B), (C) and (D)

114. Which of the following is the correct plot for the probability density $\psi^2(r)$ as a function of distance 'r' of the electron from the nucleus for 2s orbital? **[29 June, 2022 (Shift-II)]**



115. Which of the following sets of quantum numbers is not allowed? **[25 July, 2022 (Shift-I)]**

(a) $n = 3, l = 2, m_l = 0, s = +\frac{1}{2}$

(b) $n = 3, l = 2, m_l = -2, s = +\frac{1}{2}$

(c) $n = 3, l = 3, m_l = -3, s = -\frac{1}{2}$

(d) $n = 3, l = 0, m_l = 0, s = -\frac{1}{2}$

116. Given below are the quantum numbers for 4 electrons. **[29 July, 2022 (Shift-II)]**

(A) $n = 3, \ell = 2, m_l = 1, m_s = +1/2$

(B) $n = 4, \ell = 1, m_l = 0, m_s = +1/2$

(C) $n = 4, \ell = 2, m_l = -2, m_s = -1/2$

(D) $n = 3, \ell = 1, m_l = -1, m_s = +1/2$

The correct order of increasing energy is

(a) (D) < (B) < (A) < (C) (b) (D) < (A) < (B) < (C)

(c) (B) < (D) < (A) < (C) (d) (B) < (D) < (C) < (A)

117. Given below are two statements. One is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): Energy of 2s orbital of hydrogen atom is greater than that of 2s orbital of lithium.

Reason (R): Energies of the orbitals in the same subshell decrease with increase in the atomic number. **[27 July, 2022 (Shift-I)]**

In the light of the above statements, choose the **correct** answer from the options given below:

(a) Both A and R are true and R is the correct explanation of A

(b) Both A and R are true and R is NOT the correct explanation of A

(c) A is true but R is false

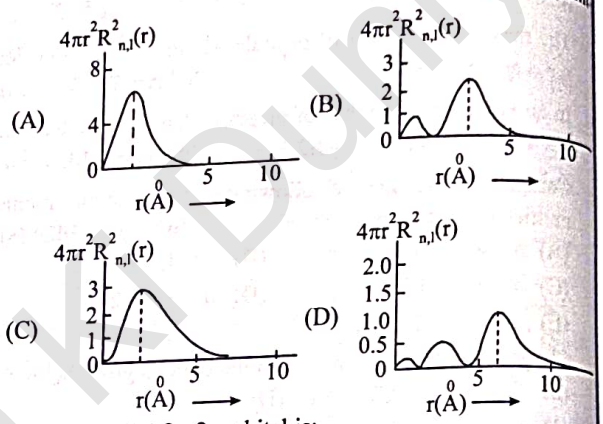
(d) A is false but R is true.

118. Consider the following set of quantum numbers. **[27 July, 2022 (Shift-I)]**

	n	l	m_l
A.	3	3	−3
B.	3	2	−2
C.	2	1	+1
D.	2	2	+2

The number of correct sets of quantum numbers is_____.

119. The Plots of radial distribution functions for various orbitals in hydrogen atom against 'r' are given below: **[25 Feb, 2021 (Shift-I)]**



The correct plot for 3s orbital is:

(a) (D) (b) (B) (c) (A) (d) (C)

120. A certain orbital has no angular nodes and two radial nodes. The orbital is: **[18 March, 2021 (Shift-I)]**

(a) 3s (b) 3p (c) 2s (d) 2p

121. The orbital having two radial as well as two angular nodes is: **[26 Feb, 2021 (Shift-I)]**

(a) 4d (b) 5d (c) 4f (d) 3p

122. A certain orbital has n = 4 and $m_l = -3$. The number of radial nodes in this orbital is _____. (Round off to the nearest integer) **[17 March, 2021 (Shift-I)]**

123. The number of orbitals with n = 5, $m_l = +2$ is_____. (Round off to the nearest integer). **[16 March, 2021 (Shift-I)]**

124. The number of subshells associated with n = 4 and m = −2 quantum numbers is: **[2 Sept, 2020 (Shift-I)]**

(a) 2 (b) 16 (c) 8 (d) 4

125. Consider the hypothetical situation where the azimuthal quantum number, l, takes values 0, 1, 2, ... n + 1, where n is the principal quantum number. Then, the element with atomic number: **[3 Sept, 2020 (Shift-I)]**

(a) 9 is the first alkali metal

(b) 8 is the first noble gas

(c) 13 has a half–filled valence subshell

(d) 6 has a 2p–valence subshell

126. The correct statement about probability density (except at infinite distance from nucleus) is: **[5 Sept, 2020 (Shift-I)]**

(a) It can be zero for 3p orbital

(b) It can be zero for 1s orbital

(c) It can be zero for 2p orbital

(d) It can be zero for 2s orbital

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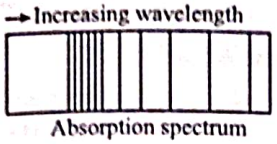
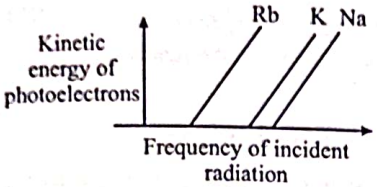
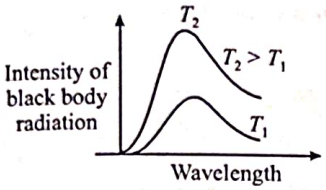
127. The number of orbitals associated with quantum number n = 5, $m_s = +½$ is [7 Jan, 2020 (Shift-I)]

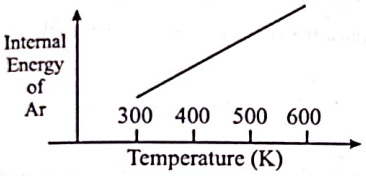
(a) 15 (b) 11 (c) 50 (d) 25

128. The figure that is not a direct manifestation of the quantum nature of atoms is: [2 Sept, 2020 (Shift-I)]

(a)


(b)


(c)


(d)


129. In the sixth period, the orbitals that are filled are: [5 Sept, 2020 (Shift-I)]

(a) 6s, 5f, 6d, 6p (b) 6s, 6p, 6d, 6f

(c) 6s, 4f, 5d, 6p (d) 6s, 5d, 5f, 6p

130. The size of the isoelectronic species Cl^-, Ar and Ca^{2+} is affected by: [8 April, 2019 (Shift-I)]

(a) Principal quantum number of valence shell.

(b) Nuclear charge.

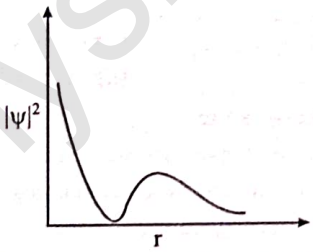
(c) Azimuthal quantum number of valence shell.

(d) Electron–electron interaction in the outer orbitals.

131. The 71st electron of an element X with an atomic number of 71 enters in to the orbital: [10 Jan, 2019 (Shift-II)]

(a) 6 p (b) 4f (c) 5d (d) 6s

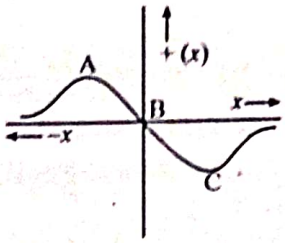
132. The graph between $|\psi|^2$ and r (radial distance) is shown below. This represents: [10 April, 2019 (Shift-I)]



(a) 3s orbital (b) 1s orbital

(c) 2p orbital (d) 2s orbital

133. The electrons are more likely to be found: [12 April, 2019 (Shift-I)]



(a) In the region (A) and (B)

(b) In the region (A) and (C)

(c) Only in the region (C)

(d) Only in the region (A)

134. Among the following the energy of 2s orbital is lowest in: [12 April, 2019 (Shift-II)]

(a) K (b) Na

(c) H (d) Li

135. Which of the following combination of statements is true regarding the interpretation of the atomic orbitals?

(A) An electron in an orbital of high angular momentum stays away from the nucleus than an electron in the orbital of lower angular momentum.

(B) For a given value of the principal quantum number, the size of the orbit is inversely proportional to the azimuthal quantum number.

(C) According to wave mechanics, the ground state angular momentum is equal to $\frac{h}{2\pi}$.

(D) The plot of (ψ) Vs (r) for various azimuthal quantum numbers, shows peak shifting towards higher r value

[9 Jan, 2019 (Shift-II)]

(a) (A), (D) (b) (A), (B)

(c) (A), (C) (d) (B), (C)

136. The quantum number of four electrons are given below; [8 April, 2019 (Shift-I)]

(I) $n = 4, l = 2, m_l = -2, m_s = -\frac{1}{2}$

(II) $n = 3, l = 2, m_l = 1, m_s = +\frac{1}{2}$

(III) $n = 4, l = 1, m_l = 0, m_s = +\frac{1}{2}$

(IV) $n = 3, l = 1, m_l = 1, m_s = -\frac{1}{2}$

The Correct order of their increasing energies will be:

(a) IV < III < II < I (b) IV < II < III < I

(c) I < II < III < IV (d) I < III < II < IV

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Subatomic Particles and Atomic Models

Single Correct

1. Rutherford's experiment, which established the nuclear model of the atom, used a beam of (IIT JEE 2002)
   (a) β-particles, which impinged on a metal foil and got absorbed
   (b) γ-rays, which impinged on a metal foil and got scattered
   (c) helium atoms, which impinged on a metal foil and got scattered
   (d) helium nuclei, which impinged on a metal foil and got scattered

2. Rutherford's alpha particle scattering experiment eventually led to the conclusion that (IIT JEE 1986)
   (a) mass and energy are related
   (b) electrons occupy space around the nucleus
   (c) neutrons are buried deep in the nucleus
   (d) the point of impact with matter can be precisely determined

3. The radius of an atomic nucleus is of the order of (IIT JEE 1985)
   (a) 10^{-10} cm (b) 10^{-13} cm
   (c) 10^{-15} cm (d) 10^{-18} cm

4. The increasing order (lowest first) for the values of e/m (charge/mass) for electron (e), proton (p), neutron (n) and alpha particle (α) is (IIT JEE 1984)
   (a) e, p, n, α (b) n, p, e, α
   (c) n, p, α, e (d) n, α, p, e

5. Rutherford's scattering experiment is related to the size of the (IIT JEE 1983)
   (a) nucleus (b) atom (c) electron (d) neutron

6. Rutherford's experiment on scattering of α-particles showed for the first time that the atom has (IIT JEE 1981)
   (a) electrons (b) protons (c) nucleus (d) neutrons

Multiple Correct

7. The atomic nucleus contains (IIT JEE 1988)
   (a) protons (b) neutrons
   (c) electrons (d) photons

8. The sum of the number of neutrons and proton in the isotopes of hydrogen is (IIT JEE 1986)
   (a) 6 (b) 5 (c) 4 (d) 3

9. When alpha particles are sent through a thin metal foil, most of them go straight through the foil, because (IIT JEE 1984)
   (a) alpha particles are much heavier than electrons
   (b) alpha particles are positively charged
   (c) most part of the atom is empty space
   (d) alpha particles move with high velocity

10. Many elements have non-integral atomic masses, because (IIT JEE 1984)
   (a) they have isotopes
   (b) their isotopes have non-integral masses
   (c) their isotopes have different masses
   (d) the constituents, neutrons, protons and electrons, combine to give fractional masses

11. An isotone of $^{76}_{32}Ge$ (IIT JEE
   (a) $^{77}_{32}Ge$ (b) $^{77}_{33}As$ (c) $^{77}_{34}Se$ (d) $^{78}_{34}Se$

Fill in the Blanks

12. Elements of the same mass number but of different atomic nu are known as ..... (IIT JEE
13. The mass of a hydrogen is ..... kg. (IIT JEE
14. Isotopes of an element differ in the number of ..... in their (IIT JEE

True/False

15. In a given electric field, β-particles are deflected mor α-particles in spite of α-particles having larger charge. (IIT JEE

Developments Leading to the Bohr's Model of Atom

Single Correct

16. The first use of quantum theory to explain the structure o was made by (IIT JEE
   (a) Heisenberg (b) Bohr
   (c) Planck (d) Einstein

17. Which of the following relates to photons both as wave mot as a stream of particles? (IIT JEE
   (a) Interference (b) $E = mc^2$
   (c) Diffraction (d) $E = hv$

18. Which of the following does not characterize X-rays? (IIT JEE
   (a) The radiation can ionise gases
   (b) It causes *ZnS* to fluoresce
   (c) Deflected by electric and magnetic fields
   (d) Have wavelengths shorter than ultraviolet rays

19. The ratio of the energy of a photon of 2000Å wavelength ra to that of 4000Å radiation is (IIT JEE
   (a) $\frac{1}{4}$ (b) 4 (c) $\frac{1}{2}$ (d) 2

20. Electromagnetic radiation with maximum wavelength is (IIT JEE
   (a) ultraviolet (b) radio wave
   (c) X-ray (d) infrared

21. Bohr's model can explain (IIT JEE
   (a) the spectrum of hydrogen atom only
   (b) spectrum of an atom or ion containing one electron on
   (c) the spectrum of hydrogen molecule
   (d) the solar spectrum

Numerical/Integer Types

22. The atomic masses of He and Ne are 4 and 20 amu, respec The value of the de-Broglie wavelength of He gas at −73°C times that of the de-Broglie wavelength of Ne at 727°C. M

C-51.1 W-21.28 UA-27.62 (JEE Adv.

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23. The work function (ϕ) of some metals is listed below. The number of metals which will show photoelectric effect when light of 300 nm wavelength falls on the metal is **(IIT JEE 2011)**

Metal	Li	Na	K	Mg	Cu	Ag	Fe	Pt	W
ϕ(eV)	2.4	2.3	2.2	3.7	4.8	4.3	4.7	6.3	4.75

Fill in the Blanks

24. The light radiations with discrete quantities of energy are called ..... **(IIT JEE 1993)**

True/False

25. Gamma rays are electromagnetic radiations of wavelengths of 10^{-6} to 10^{-5} cm **(IIT JEE 1983)**

Subjective

26. Calculate the wave number for the shortest wavelength transition in the Balmer series of atomic hydrogen. **(IIT JEE 1996)**

27. Iodine molecule dissociates into atoms after absorbing light to 4500Å. If one quantum of radiation is absorbed by each molecule, calculate the kinetic energy of iodine atoms. (Bond energy of I_2 = 240 kJ mol^{-1}) **(IIT JEE 1995)**

28. What transition in the hydrogen spectrum would have the same wavelength as the Balmer transition n = 4 to n = 2 of He^+ spectrum? **(IIT JEE 1993)**

Bohr's Model for Hydrogen Atom

Single Correct

29. According to Bohr's model, the highest kinetic energy is associated with the electron in the
C-63.34 W-30.87 UA-5.79 (JEE Adv. 2024)
(*a*) first orbit of H atom (*b*) first orbit of He^+
(*c*) second orbit of He^+ (*d*) second orbit of Li^{2+}

30. The kinetic energy of an electron in the second Bohr orbit of a hydrogen atom is (a_0 is Bohr radius).
C-15.62 W-49.46 UA - 34.92 (IIT JEE 2012)
(*a*) $\frac{h^2}{4\pi^2 m a_0^2}$ (*b*) $\frac{h^2}{16\pi^2 m a_0^2}$
(*c*) $\frac{h^2}{32\pi^2 m a_0^2}$ (*d*) $\frac{h^2}{64\pi^2 m a_0^2}$

31. Which hydrogen like species will have same radius as that of Bohr orbit of hydrogen atom? **(IIT JEE 2004)**
(*a*) n = 2, Li^{2+} (*b*) n = 2, Be^{3+}
(*c*) n = 2, He^+ (*d*) n = 3, Li^{2+}

32. The energy of an electron in the first Bohr orbit of H-atom is – 13.6eV. The possible energy value(s) of the excited state(s) for electrons in Bohr orbits of hydrogen is (are) **(IIT JEE 1998)**
(*a*) –3.4eV (*b*) –4.2eV
(*c*) –6.8eV (*d*) +6.8eV

33. The wavelength of a spectral line for an electronic transition is inversely related to **(IIT JEE 1988)**
(*a*) the number of electrons undergoing the transition
(*b*) the nuclear charge of the atom
(*c*) the difference in the energy of the energy levels involved in the transition
(*d*) the velocity of the electron undergoing the transition

34. Which electronic level would allow the hydrogen atom to absorb a photon but not to emit a photon? **(IIT JEE 1984)**
(*a*) 3s (*b*) 2p
(*c*) 2s (*d*) 1s

Comprehensive/Passage Based

Consider the Bohr's model of a one-electron atom where the electron moves around the nucleus. In the following List-I contains some quantities for the nth orbit of the atom and List-II contains options showing how they depend on n.

	List-I		List-II
(I)	Radius of the nth orbit	(P)	$\propto n^{-2}$
(II)	Angular momentum of the electron in the nth orbit	(Q)	$\propto n^{-1}$
(III)	Kinetic energy of the electron in the nth orbit	(R)	$\propto n^0$
(IV)	Potential energy of the electron in the nth orbit	(S)	$\propto n^1$
		(T)	$\propto n^2$
		(U)	$\propto n^{1/2}$

35. Which of the following options has the correct combination considering List-I and List-II?
C-75.83 W-17.64 UA-6.53 (JEE Adv. 2019)
(*a*) (II), (R) (*b*) (I), (P)
(*c*) (I), (T) (*d*) (II), (Q)

36. Which of the following options has the correct combination considering List-I and List-II?
C-70.33 W-20.49 UA-9.19 (JEE Adv. 2019)
(*a*) (III), (S) (*b*) (IV), (Q)
(*c*) (IV), (U) (*d*) (III), (P)

37. According to Bohr's theory,
E_n = Total energy K_n = Kinetic Energy V_n = Potential Energy
r^n = Radius of nth orbit **(IIT JEE 2006)**

	Column-I		Column-II
A.	$V_n / K_n = ?$	p.	0
B.	If radius of *n*-th orbit $\propto E_n^x, x = ?$	q.	–1
C.	Angular momentum in lowest	r.	–2
D.	$\frac{1}{r^n} \propto Z^y, y = ?$	s.	1

Numerical/Integer Types

38. For He^+, a transition takes place from the orbit of radius 105.8 pm to the orbit of radius 26.45 pm. The wavelength (in nm) of the emitted photon during the transition is ___.
[Use: Bohr radius, a = 52.9 pm
Rydberg constant, $R_H = 2.2 \times 10^{-18}$ J
Planck's constant, $h = 6.6 \times 10^{-34}$ J s
Speed of light, $c = 3 \times 10^8$ m s^{-1}]
C-11.93 W-66.52 UA-21.55 (JEE Adv. 2023)

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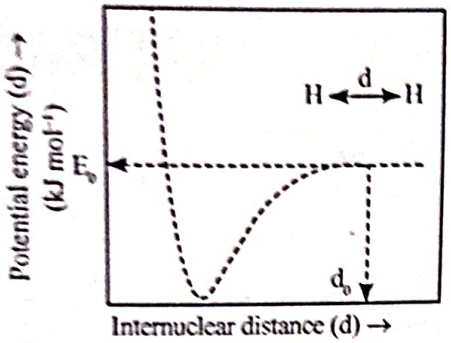
39. The figure below is the plot of potential energy versus internuclear distance (d) of H_2 molecule in the electronic ground state. What is the value of the net potential energy E_0 (as indicated in the figure) in kJ mol^{-1}, for d = d_0 at which the electron-electron repulsion and the nucleus-nucleus repulsion energies are absent? As reference, the potential energy of H atom is taken as zero when its electron and the nucleus are infinitely far apart.

Use Avogadro constant as 6.023×10^{23} mol^{-1}.

C-0.14 W-65.68 UA-34.18 (JEE Adv. 2020)



Fill in the Blanks

40. 8 g each of oxygen and hydrogen at 27°C will have the total kinetic energy in the ratio of ..... **(IIT JEE 1989)**

Subjective

41. (*a*) Calculate velocity of electron in first Bohr orbit of hydrogen atom (Given r = a_0).

(*b*) Find de-Broglie wavelength of the electron in first Bohr orbit.

(*c*) Find the orbital angular momentum of 2*p*-orbital in terms of $h / 2\pi$ units. **(IIT JEE 2005)**

42. The wavelength corresponding to maximum energy for hydrogen is 91.2 nm. Find the corresponding wavelength for He^+ ion **(IIT JEE 2003)**

43. Calculate the energy required to excite 1 L of hydrogen gas at 1 atm and 298 K to the first excited state of atomic hydrogen. The energy for the dissociation of H – H bond is 436 kJ mol^{-1}. **(IIT JEE. 2000)**

44. With what velocity should an α-particle travel towards the nucleus of a copper atom so as to arrive at a distance 10^{-13} *m* from the nucleus of the copper atom? **(IIT JEE 1997)**

45. Consider the hydrogen atom to be proton embedded in a cavity of radius a_0 (Bohr's radius) whose charge is neutralised by the addition of an electron to the cavity in vacuum, infinitely slowly. Estimate the average total energy of an electron in its ground state in a hydrogen atom as the work done in the above neutralisation process. Also, if the magnitude of the average kinetic energy is half the magnitude of the average potential energy, find the average potential energy. **(IIT JEE 1996)**

46. Find out the number of waves made by a Bohr's electron in one complete revolution in its 3rd orbit. **(IIT JEE 1994)**

47. Estimate the difference in energy between 1st and 2nd Bohr's orbit for a hydrogen atom. At what minimum atomic number, a transition from $n = 2$ to $n = 1$ energy level would result in the emission of X-rays with $l = 3.0 \times 10^{-8}$ *m*? Which hydrogen atom-like species does this atomic number correspond to? **(IIT JEE 1993)**

48. According to Bohr's theory, the electronic energy of hydroge in the nth Bohr's orbit is given by:

$$E_n = \frac{-21.7 \times 10^{-19}}{n^2} J$$

Calculate the longest wavelength of electron from the third orbit of the He^+ ion **(IIT JEE**

49. The electron energy in hydrogen atom is given by $E_n = -\frac{21.7\times}{n^2}$ erg. Calculate the energy required to remove an electron comp from the n = 2 orbit. What is the longest wavelength (in c light that can be used to cause this transition? **(IIT JEE**

50. Calculate the wavelength in Angstroms of the photon that is e when an electron in the Bohr's orbit, $n = 2$ returns to the $n = 1$ in the hydrogen atom. The ionisation potential of the g state hydrogen atom is 2.17×10^{-11} *erg* per atom. **(IIT JEE**

51. The energy of the electron in the second and third Bohr's of the hydrogen atom is -5.42×10^{-12} erg and -2.41×10 respectively. Calculate the wavelength of the emitted light the electron drops from the third to the second orbit. **(IIT JEE**

Towards Quantum Mechanical Model of the Atom

Single Correct

52. The wavelength associated with a golf ball weighing 200 moving at a speed of 5 m / h is of the order **(IIT JEE**

(*a*) 10^{-10} m (*b*) 10^{-20} m

(*c*) 10^{-30} m (*d*) 10^{-40} m

Numerical/Integer Types

53. Consider a Helium (He) atom that absorbs a photon of wavel 330 nm. The change in the velocity (in cm s^{-1}) of He atom aft photon absorption is _____.

(Assume: Momentum is conserved when photon is absorbe

Use: Planck constant = 6.6×10^{-34} Js, Avogadro number = 6 mol^{-1}, molar mass of He = 4 g mol^{-1}

C-7.56 W-73.79 UA-18.65 (JEE Adv.

Fill in the Blanks

54. The uncertainty principle and the concept of wave nature of m were proposed by ..... and ..... respectively **(IIT JEE**

Subjective

55. An electron beam can undergo diffraction by crystals. Thr what potential should a beam of electrons be accelerated so its wavelength becomes equal to 1.54Å. **(IIT JEE**

Quantum Mechanical Model of the Atom

Single Correct

56. P is the probability of finding the 1s electron of hydrogen ato a spherical shell of infinitesimal thickness, dr, at a distance r the nucleus. The volume of this shell is $4\pi r^2$ dr. The qualit sketch of the dependence of P on r is

C-37.22 W-37.41 UA-25.38 (JEE Adv. 2

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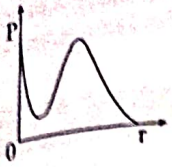
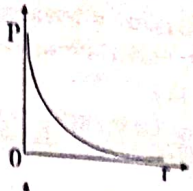
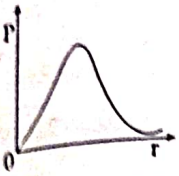
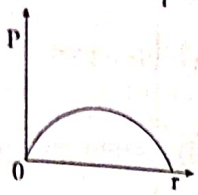
(a) 

(b) 

(c) 

(d) 

57. The number of radial nodes in 3s and 2p respectively are **(IIT JEE 2005)**

(a) 2 and 0 (b) 0 and 2 (c) 1 and 2 (d) 2 and 1

58. If the nitrogen atom had electronic configuration $1s^7$, it would have energy lower than that of the normal ground state configuration $1s^2 2s^2 2p^3$, because the electrons would be closer to the nucleus, yet $1s^7$ is not observed, because it violates **(IIT JEE 2002)**

(a) Heisenberg uncertainty principle
(b) Hund's rule
(c) Pauli exclusion principle
(d) Bohr postulate of stationary orbits

59. The quantum numbers $+\frac{1}{2}$ and $-\frac{1}{2}$ for the electron spin represent **(IIT JEE 2001)**

(a) rotation of the electron in clockwise and anti-clockwise direction respectively
(b) rotation of the electron in anti-clockwise and clockwise direction respectively
(c) magnetic moment of the electron pointing up and down respectively
(d) two quantum mechanical spin states which have no classical analogue

60. The number of nodal planes in a p_x orbital is **(IIT JEE 2001)**

(a) one (b) two (c) three (d) zero

61. The electronic configuration of an element is $1s^2, 2s^2 2p^6, 3s^2 3p^6 3d^5, 4s^1$. This represents its **(IIT JEE 2000)**

(a) excited state (b) ground state
(c) cationic form (d) anionic form

62. The electrons, identified by quantum numbers n and l, (i) $n = 4, l = 1$, (ii) $n = 4, l = 0$, (iii) $n = 3, l = 2$, (iv) $n = 3, l = 1$ can be placed in order of increasing energy, from the lowest to highest, as **(IIT JEE 1999)**

(a) (iv) < (ii) < (iii) < (i) (b) (ii) < (iv) < (i) < (iii)
(c) (i) < (iii) < (ii) < (iv) (d) (iii) < (i) < (iv) < (ii)

63. For a d-electron, the orbital angular momentum is **(IIT JEE 1997)**

(a) $\sqrt{6}\left(\frac{h}{2\pi}\right)$ (b) $\sqrt{2}\left(\frac{h}{2\pi}\right)$ (c) $\left(\frac{h}{2\pi}\right)$ (d) $2\left(\frac{h}{2\pi}\right)$

64. The orbital angular momentum of an electron in 2s-orbital is **(IIT JEE 1996)**

(a) $+\frac{1}{2}\cdot\frac{h}{2\pi}$ (b) zero
(c) $\frac{h}{2\neq}$ (d) $\sqrt{2}\cdot\frac{h}{2\neq}$

65. The outermost electronic configuration of the most electronegative element is **(IIT JEE 1990)**

(a) $ns^2 np^3$ (b) $ns^2 np^4$
(c) $ns^2 np^5$ (d) $ns^2 np^6$

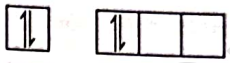
66. The correct set of quantum numbers for the unpaired electron of chlorine atom is **(IIT JEE 1989)**

(a) $n = 2, \ell = 1, m = 0$ (b) $n = 2, \ell = 1, m = 1$
(c) $n = 3, \ell = 1, m = 1$ (d) $n = 3, \ell = 0, m = 0$

67. The correct ground state electronic configuration of chromium atom is **(IIT JEE 1989)**

(a) $[Ar]3d^5 4s^1$ (b) $[Ar]3d^4 4s^2$
(c) $[Ar]3d^6 4s^0$ (d) $[Ar]4d^5 4s^1$

68. The orbital diagram in which the Aufbau principle is violated **(IIT JEE 1988)**

(a)  (b)

(c) (d)

69. Which one of the following sets of quantum numbers represents an impossible arrangement for n, l, m, s? **(IIT JEE 1986)**

(a) $\left(3, 2, -2, \frac{1}{2}\right)$ (b) $4, 0, 0, \frac{1}{2}$
(c) $3, 2, -3, \frac{1}{2}$ (d) $5, 3, 0, -\frac{1}{2}$

70. Correct set of four quantum numbers for the valence (outermost) electron of rubidium ($Z = 37$) is **(IIT JEE 1984)**

(a) $5, 0, 0, +\frac{1}{2}$ (b) $5, 0, 1, +\frac{1}{2}$
(c) $5, 1, 1, +\frac{1}{2}$ (d) $6, 0, 0, +\frac{1}{2}$

71. The principal quantum number of an atom is related to the **(IIT JEE 1983)**

(a) size of the orbital
(b) spin angular momentum
(c) orientation of the orbital in space
(d) orbital angular momentum

72. Any *p*-orbital can accommodate upto **(IIT JEE 1983)**

(a) four electrons
(b) six electrons
(c) two electrons with parallel spins
(d) two electrons with opposite spins

Multiple Correct

73. Among the following, the correct statement(s) for electrons in an atom is(are) **C-11.8 W-20.77 UA-11.65 PC-55.78 (JEE Adv. 2024)**

(a) Uncertainty principle rules out the existence of definite paths for electrons.
(b) The energy of an electron in 2*s* orbital of an atom is lower than the energy of an electron that is infinitely far away from the nucleus.
(c) According to Bohr's model, the most negative energy value for an electron is given by n = 1, which corresponds to the most stable orbit.
(d) According to Bohr's model, the magnitude of velocity of electrons increases with increase in values of n.

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74. The ground state energy of hydrogen atom is –13.6 eV. Consider an electronic state of He^+ whose energy, azimuthal quantum number and magnetic quantum number are –3.4 eV, 2 and 0, respectively.

Which of the following statement(s) is (are) true for the state Ψ?

C-23.82 W-41.54 UA-20.07 PC-14.57 (JEE Adv. 2019)

(a) It is a 4 d state

(b) The nuclear charge experienced by the electron in this state is less than 2e, where e is the magnitude of the electronic charge

(c) It has 2 angular nodes

(d) It has 3 radial nodes

75. The ground state electronic configuration of nitrogen atom can be represented by **(IIT JEE 1999)**

(a) ↑↓ ↑↓ ↑ ↑ ↑ (b) ↑↓ ↑↓ ↑ ↓ ↑

(c) ↑↓ ↑↓ ↑ ↓ ↓ (d) ↑↓ ↑↓ ↓ ↓ ↓

76. Which of the following statement (s) is (are) correct? **(IIT JEE 1998)**

(a) The electronic configuration of Cr is $[Ar]3d^5 4s^1$ (atomic number of Cr = 24)

(b) The magnetic quantum number may have a negative value

(c) In silver atom, 23 electrons have a spin of one type and 24 of the opposite type. (Atomic number of Ag = 47)

(d) The oxidation state of nitrogen in HN_3 is –3

Assertion Reason/Statement Based

Read the following questions and answer as per the direction given below:

(a) Statement-I is correct; Statement-II is correct Statement-II is the correct explanation of Statement-I

(b) Statement-I is correct; Statement-II is correct Statement-II is not the correct explanation of Statement-I

(c) Statement-I is correct; Statement-II is incorrect

(d) Statement-I is incorrect; Statement-II is correct

77. **Statement-I:** The first ionisation energy of Be in greater than that of B.

Statement-II: 2p-orbital is lower in energy than 2s. **(IIT JEE 2000)**

Comprehension/Passage Based

The hydrogen-like species Li^{2+} is in a spherically symmetric state S_1 with one radial node. Upon absorbing light, the ion undergoes transition to a state S_2. The state S_2 has one radial node and its energy is equal to the ground state energy of the hydrogen atom.

. The state S_1 is **(IIT JEE 2010)**

(a) 1s (b) 2s (c) 2p (d) 3s

. Energy of the state S_1 in units of the hydrogen atom ground state energy is **(IIT JEE 2010)**

(a) 0.75 (b) 1.50 (c) 2.25 (d) 4.50

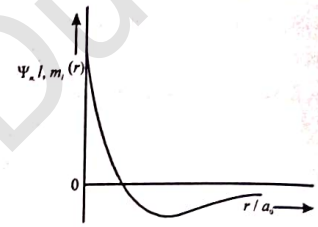
The orbital angular momentum quantum number of the state S_2 is **(IIT JEE 2010)**

(a) 0 (b) 1 (c) 2 (d) 3

Match the Column

The wave function, ψ_{n,l,m_l} is a mathematical function whose value depends upon spherical polar coordinates (r, θ, ϕ) of the electron and characterised by the quantum number n, l and m_l. Here r is distance from nucleus, θ is colatitude and ϕ is azimuth mathematical functions given in the Table, Z is atomic num a_0 is Bohr radius.

	Column-I		Column-II
(I)	1s-orbital	(i)	$\psi_{n,l,m_l} \propto \left(\frac{Z}{a_0}\right)^{\frac{3}{2}} e^{-\left(\frac{Zr}{a_0}\right)}$
(II)	2s-orbital	(ii)	one radial node
(III)	$2p_z$ - orbital	(iii)	$\psi_{n,l,m_l} \propto \left(\frac{Z}{a_0}\right)^{\frac{5}{2}} re^{-\left(\frac{Zr}{a_0}\right)}$
(IV)	$3d_z^2$ – orbital	(iv)	xy-plane is a nodal pla

	Column-III
(P)	
(Q)	Probability density at nucleus $\propto \frac{1}{a_0^3}$
(R)	Probability density is maximum at nucleus
(S)	Energy needed to excite electron from n = 2 state to n state is $\frac{27}{32}$ times the energy needed to excite elect from n = 2 state to n = 6.

81. For He^+ ion, the only INCORRECT combination is

C-16.69 W-40.53 UA-42.78 (JEE Adv

(a) (I) (i) (S) (b) (II) (ii) (Q)

(c) (I) (iii) (R) (d) (I) (i) (R)

82. For the given orbital in Column-I, the only CORRECT comb for nay hydrogen-like species is

C-28.59 W-30.39 UA-41.01 (JEE Adv.

(a) (II) (ii) (P) (b) (I) (ii) (S)

(c) (IV) (iv) (R) (d) (III) (iii) (P)

83. For hydrogen atom, the only CORRECT combination is

C-32.01 W-30.18 UA-37.8 (JEE Adv.

(a) (I) (i) (P) (b) (I) (iv) (R)

(c) (II) (i) (Q) (d) (I) (i) (S)

Numerical/Integer Types

84. Not considering the electronic spin, the degeneracy of the s excited state (n = 3) of H-atom is 9 , while the degeneracy second excited state of H^- is **(JEE Adv.**

85. In an atom, the total number of electrons having quantum nu

$n = 4, |m_l| = 1$ and $m_s = -\frac{1}{2}$ is

C-26.82 W-69.72 UA- 3.46 (JEE Adv.

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86. The maximum number of electrons that can have principal quantum number, $n = 3$ and spin quantum number, $m_s = -1/2$, is **(IIT JEE 2011)**

Fill in the Blanks

87. The outermost electronic configuration of Cr is _____. **(IIT JEE 1994)**

88. Wave functions of electrons in atoms and molecules are called _____. **(IIT JEE 1993)**

89. The $2p_x$, $2p_y$ and $2p_z$ orbitals of atom have identical shapes but differ in their _____. **(IIT JEE 1993)**

90. When there are two electrons in the same orbital, they have _____ spins **(IIT JEE 1983)**

True/False

91. The electron density in the XY-plane in $3d_{x^2-y^2}$ orbital zero. **(IIT JEE 1986)**

92. The energy of the electron in the 3d-orbital is less than that in the 4s orbital in the hydrogen atom. **(IIT JEE 1983)**

93. The outer electronic configuration of the ground state chromium atom is $3d^4 4s^2$. **(IIT JEE 1982)**

Subjective

94. (*a*) The Schrodinger wave equation for hydrogen atom is

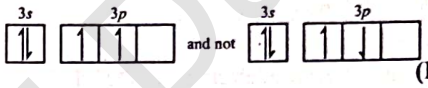
$$\psi_{2s} = \frac{1}{4(2\pi)^{1/2}}\left(\frac{1}{a_0}\right)^{3/2}\left(2-\frac{r}{a_0}\right)e^{-r/2a_0}$$

where, a_0 is Bohr's radius. Let the radial node in 2s be at r_0. Then, find r_0 in terms of a_0.

(*b*) A base ball having mass 100 g moves with velocity 100 m/s. Find out the value of wavelength of baseball. **(IIT JEE 2004)**

95. What is the maximum number of electrons that may be present in all the atomic orbitals with principal quantum number 3 and azimuthal quantum number 2? **(IIT JEE 1985)**

96. Give reason why the ground state outermost electronic configuration of silicon is



(IIT JEE 1985)

ANSWER KEY

JEE-MAIN

1. (*d*)	2. (*b*)	3. [4]	4. (*d*)	5. (*b*)	6. (*d*)	7. (*d*)	8. [494]	9. (*b*)	10. [5]
11. [1724]	12. (*b*)	13. [7]	14. [0]	15. [2]	16. [1]	17. [3]	18. [798]	19. (*c*)	20. [300]
21. (*c*)	22. [6]	23. [5]	24. [2]	25. [2]	26. [181]	27. [2]	28. [50]	29. [9]	30. [222]
31. (*b*)	32. (*d*)	33. (*c*)	34. (*c*)	35. [54]	36. (*d*)	37. (*c*)	38. (*a*)	39. (*c*)	40. (*d*)
41. (*c*)	42. [10]	43. [8]	44. [22]	45. [34]	46. (*b*)	47. (*c*)	48. (*a*)	49. (*d*)	50. (*c*)
51. [492]	52. [270]	53. [1]	54. (*b*)	55. [10]	56. [2]	57. [*]	58. (*d*)	59. (*a*)	60. (*a*)
61. [3155]	62. (*c*)	63. (*c*)	64. (*a*)	65. (*c*)	66. (*c*)	67. (*b*)	68. (*d*)	69. (*d*)	70. (*d*)
71. (*a*)	72. (*d*)	73. (*d*)	74. (*a*)	75. (*a*)	76. [*]	77. [58]	78. (*d*)	79. [22]	80. [1758]
81. [548]	82. [58]	83. (*d*)	84. (*d*)	85. (*b*)	86. (*c*)	87. (*d*)	88. (*d*)	89. (*d*)	90. (*b*)
91. (*b*)	92. (*d*)	93. (*d*)	94. [16]	95. (*a*)	96. (*a*)	97. (*b*)	98. (*a*)	99. [4]	100. [6]
101. (*d*)	102. (*b*)	103. (*b*)	104. [5.00]	105. [3]	106. (*c*)	107. [0]	108. (*a*)	109. (*a*)	110. (*d*)
111. (*a*)	112. (*b*)	113. (*c*)	114. (*b*)	115. (*c*)	116. (*b*)	117. (*a*)	118. [2]	119. (*a*)	120. (*a*)
121. (*b*)	122. [0]	123. [3]	124. (*a*)	125. (*c*)	126. (*a*)	127. (*d*)	128. (*c*)	129. (*c*)	130. (*b*)
131. (*c*)	132. (*d*)	133. (*b*)	134. (*a*)	135. (*c*)	136. (*b*)				

JEE-ADVANCED

1. (*d*)	2. (*b*)	3. (*b*)	4. (*d*)	5. (*a*)	6. (*c*)	7. (*a, b*)	8. (*a*)	9. (*a, c*)	10. (*a, c*)
11. (*b,d*)	12. Isobars	13. 1.66×10^{-27} kg		14. Neutrons	15. TRUE	16. (*b*)	17. (*d*)	18. (*c*)	19. (*d*)
20. (*b*)	21. (*b*)	22. [5]	23. [4]	24. Photons	25. FALSE	29. (*b*)	30. (*c*)	31. (*b*)	32. (*a*)
33. (*c*)	34. (*d*)	35. (*c*)	36. (*d*)	37. A → (r); B → (q) ; C → (p) ; D → (s)			38. [30]	39. [−5242.4192]	
40. [1:16]	41. (*a*)	52. (*c*)	53. [30]	54. Heisenberg and De Broglie			56. (*c*)	57. (*a*)	58. (*c*)
59. (*d*)	60. (*a*)	61. (*b*)	62. (*a*)	63. (*a*)	64. (*b*)	65. (*c*)	66. (*c*)	67. (*a*)	68. (*b*)
69. (*c*)	70. (*a*)	71. (*a*)	72. (*d*)	73. (*a,b,c*)	74. (*a, c*)	75. (*a, d*)	76. (*a, b, c*)	77. (*c*)	78. (*b*)
79. (*c*)	80. (*b*)	81. (*c*)	82. (*a*)	83. (*d*)	84. [3]	85. [6]	86. [9]	87. $[Ar]3d^5 4s^1$	
88. Orbital	89. Orientation in space		90. Opposite	91. FALSE	92. TRUE	93. FALSE			

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JEE-Main

1. **(d)** Loss of electron from hydrogen atom results in H^+ ion. Due to extremely small in size it does not exist freely. Hence, both A and R are correct but R is not the correct explanation of A.

2. **(b)**

(a) $V_e = 1000$ m/s ; $h = 6 \times 10^{-34}$ Js ; $m_e = 9 \times 10^{-31}$ kg

$$\lambda = \frac{h}{mv} = \frac{6 \times 10^{-34}}{9 \times 10^{-31} \times 1000}$$

$= 666.67 \times 10^{-9}$ m

$= 666.67$ nm

(b) The characteristic of electrons emitted is independent of the material of the electrodes of the cathode ray tube.

(c) The cathode rays start from cathode and move towards anode.

(d) The nature of the emitted electrons is independent on the nature of the gas present in cathode ray tube.

3. **[4]** In the imaginary ion,

$^{48}_{22}X^{2+}$ Number of neutrons = 48 – 22 = 26

Number of electrons = 22 + 3 = 25

$$\% \text{ of extra electrons} = \frac{26-25}{25} \times 100$$

= 4%

4. **(d)** On passing alpha particles through the gold foil, they get deflected because according to Thompson model, positive charge is dispersed throughout the atom. Also, due to repulsion from protons, their speed decreases.

(b) Statement given in option b is not proposed by Dalton.

(d) $\lambda = \frac{C}{v} = \frac{3 \times 10^8}{5.16 \times 10^{14}}$

= 581.39 nm

λ_{Phase} is near & below yellow light it can show photoelectric effect.

Decreasing the intensity of light results in decrease in the photoelectric current.

Red light will not produce the photoelectric effect because its photon energy is below the required threshold frequency.

$\nu > \nu_{Yellow}$ so photoelectric current will be produced.

White light, containing all frequencies, induce the photoelectric effect as it includes frequencies above the threshold.

So, the correct statements are A, B, D, E.

7. **(d)** The formula to calculate wavelength is:

$$\frac{1}{\lambda} = R_H Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

Given: $\lambda = 900$ nm $= 900 \times 10^{-7}$ cm

$= 9 \times 10^{-5}$ cm

$$\Rightarrow \frac{1}{\lambda \times R_H} = \frac{1}{n_1^2} - \frac{1}{n_2^2}$$

($\because Z = 1$ for H-atom)

$$\Rightarrow \frac{1}{9 \times 10^{-5} \text{ cm} \times 10^5 \text{ cm}^{-1}} = \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

($R_H = 1.09 \times 10^5$ cm^{-1})

$$\Rightarrow \frac{1}{n_1^2} - \frac{1}{n_2^2} = \frac{1}{9}$$

The above formula is valid for $n_1 = 3$, $n_2 = \infty$.

8. **[494]** Given: Wavelength (in nm)

= 242 nm

$$E = \frac{hc}{\lambda}$$

$$= \frac{4.1356 \times 10^{-15} \text{eVs} \times 3 \times 10^8 \text{ms}^{-1}}{242 \times 10^{-9} \text{m}}$$

$$= \frac{12.40 \times 10^{-7}}{242 \times 10^{-9}} \text{eV} = \frac{1240}{242} \text{eV}$$

= 5.1239 eV

$= 5.1239 \times 1.6 \times 10^{-19}$ J/atom

(Since, 1 eV = 1.6×10^{-19} J/atom)

$= 8.198 \times 10^{-19}$ J/atom = 494 kJ/mol

9. **(b)** Based on fact

10. **[5]** $\lambda = 1.5 \times 4$ pm

$= 6 \times 10^{-12}$ metre

$\lambda v = C$

$6 \times 10^{-12} \times v = 3 \times 10^8$

$$v = \frac{3 \times 10^8}{6 \times 10^{-12}}$$

$v = 5 \times 10^{19}$ Hz

Therefore, $x = 5$

11. **[1724]** $\bar{v}(\text{wave no.}) = \frac{1}{\lambda}$

Given $\lambda = 5800$ Å

$= 5800 \times 10^{-8}$ cm

$$\frac{1}{\lambda} = \frac{1}{5800 \times 10^{-8} \text{ cm}} = 17241$$

OR

1724×10 cm^{-1} $\Rightarrow x = 1724$

12. **(b)** Photoelectric effect is the ejection of electron from the metal surface when beam of suitable frequency shines on it. There will be minimum frequency ν_0 (Threshold frequency) below which photoelectric effect is not observed. The ejected electrons leave with a fixed amount of kinetic energy at a fixed $\nu > \nu_0$ with an increase in light frequency of these electron kinetic energies also.

13. **[7]** Acc. to de- Broglie

$$\lambda_d = \frac{h}{mv} = \frac{h}{\sqrt{2mKE}}$$

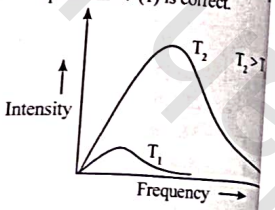
$$= \frac{6.6 \times 10^{-34}}{\sqrt{2 \times 9 \times 10^{-31} \times 4.5 \times 10^{-29}}}$$

$$= \frac{6.6 \times 10^{-34}}{\sqrt{9^2 \times 10^{-60}}}$$

$$= \frac{6.6 \times 10^{-34}}{9 \times 10^{-30}} = \frac{6.6}{9} \times 10^{-4}$$

$= 0.733 \times 10^{-4} = 7.3 \times 10^{-5}$ m

14. **[0]** A blackbody can emit and all the wavelengths in electromagnetic spectrum ⇒ (1) is correct.



⇒ (2), (3), (4) correct.

15. **[2]** The spectrum of Black body radiation is explained by the phenomenon quantization of energy. With increase temperature, peak of spectrum get shifted to shorter wavelength or higher frequency. For above graph; the correct order is $T_1 > T_2 > T_3 > T_4$.

16. **[1]** The emission spectra of atoms in the gas phase, on the other hand, shows a continuous as all of wavelengths of the visible light.

Statement (2) is incorrect.

17. **[3]** $E(\text{eV}) = \frac{1240}{400} = 3.1$ eV

Mg, Cu, Ag

18. **[798]** For one photon E = hν

For one mole photon,

$E = 6.023 \times 10^{23} \times 6.626 \times 10^{-34} \times 2$

$= 798.16$ J ≈ 798 J

19. **(c)** The formula to calculate energy for 1 photon $= \frac{hc}{\lambda}$

Energy of 1 mole of photon $= N_A \times \frac{hc}{\lambda}$

$$= \frac{6.022 \times 10^{23} \times 6.63 \times 10^{-34} \times 3 \times 10^8}{300 \times 10^{-9}}$$

$= 0.399 \times 10^6$ J = 399 kJ

20. **[300]** Given: Work function, $w_0 = 6.63 \times 10^{-19}$ J

Threshold wavelength, $\lambda_0 = ?$

Using ; $w_0 = h\nu_0 = \frac{hc}{\lambda_0}$

or, $\lambda_0 = \frac{hc}{w_0}$

on substituting values,

$$= \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{6.63 \times 10^{-19}} \text{m}$$

$= 3 \times 10^{-7}$ m

$\lambda_0 = 300 \times 10^{-9}$ m = 300nm

21. **(c)** The minimum energy possessed by the photons will be equal to the work function of the metal.

$\phi_0 = h\nu_0$

$= 6.6 \times 10^{-34} \times 1.3 \times 10^{15}$ J

$= 8.58 \times 10^{-19}$ J

22. **[6]** The formula to calculate λ in terms of potential difference is:

$$\lambda = \frac{h}{\sqrt{2 \times m \times q \times V}}$$

$$= \frac{6.63 \times 10^{-34}}{\sqrt{2 \times 9.1 \times 10^{-31} \times 1.6 \times 10^{-19} \times 40000}} \text{m}$$

$\therefore \lambda = 0.614 \times 10^{-11}$ m

$\lambda = 6.14 \times 10^{-12}$ m [Nearest integer = 6]

23. **[5]** In photo- electric effect;

$$\frac{hc}{\lambda} = h\nu_0 + \frac{1}{2}mv^2$$

Given: $h = 6.63 \times 10^{-34}$ Js,

$m = 9.0 \times 10^{-31}$ kg

$\lambda = 500 \times 10^{-9}$ m

$\nu_0 = 4.3 \times 10^{14}$ Hz

$$\frac{6.63 \times 10^{-34} \times 3 \times 10^8}{500 \times 10^{-9}} =$$

$(6.63 \times 10^{-34} \times 4.3 \times 10^{14})$

$$+ \frac{1}{2} \times 9.0 \times 10^{-31} \times v^2$$

$3.978 \times 10^{-19} = 2.85 \times 10^{-19} + 4.5 \times 10^{-31} \times v^2$

$$v = \sqrt{\frac{(3.978 \times 10^{-19} - 2.85 \times 10^{-19})}{4.5 \times 10^{-31}}}$$

$= \sqrt{25 \times 10^{10}}$

$= 5 \times 10^5$ m/s

24. **[2]** Power = 50 watt = 50 J/sec

Energy emitted per second = 50 J

Wavelength ; λ = 795nm

The formula to calculate energy (E) is:

Energy of one photon $= \frac{hc}{\lambda}$

$$= \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{795 \times 10^{-9}} \text{J}$$

$= 0.025 \times 10^{-17}$ J

Number of photons emitted per second

$$= \frac{50}{0.025 \times 10^{-17}} = 2 \times 10^{19}$$

25. **[2]** The formula to calcular λ is:

$$\lambda = \frac{h}{\sqrt{2qVm}}$$

For Li,

$$\lambda_{Li} = \frac{h}{\sqrt{2 \times 3e \times V \times 8.3m}}$$

For p,

$$\lambda_p = \frac{h}{\sqrt{2 \times e \times V \times m}}$$

Ratio is:

$$\frac{\lambda_{Li}}{\lambda_p} = \sqrt{\frac{2eVm}{2 \times 24.9eVm}}$$

$= 0.2 = 2 \times 10^{-1}$

26. **[181]** The formula to calculate energy (E) is:

$$E = \frac{hc}{\lambda} = \left\{\frac{6.63 \times 10^{-34} \times 3 \times 10^8}{663 \times 10^{-9}}\right\}$$

$= 0.03 \times 10^{-17} = 3.0 \times 10^{-19}$ J/atom

$= (3.0 \times 10^{-19} \times 6.02 \times 10^{23} \times 10^{-3})$ kJ/mol

$= 18.06 \times 10^1$ kJ/mole = 180.6 ≈ 181 kJ/mole

27. **[2]** ∴ $E = E_0 + K.E$

λ = 400 nm is sufficient to eject electron

Energy can be calculated as:

$$E = E_0 = \frac{hc}{\lambda} = \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{400 \times 10^{-9}}$$

$$= \frac{6.626 \times 3}{4} \times 10^{(-34+15)}$$

$= 4.965 \times 10^{-19}$ J

Number of e^- ejected

$$= \frac{100}{4.965 \times 10^{-19}} = 20.14 \times 10^{19}$$

$= 2.01 \times 10^{20}$

28. **[50]** Energy of emitted photon in 0.1 sec

$= 0.1 \times 10^{-3}$ Js^{-1} $= 10^{-4}$ Js^{-1}

Given: λ = 1000 nm = $10^3 \times 10^{-9}$ m = 10^{-6} m

$$n \times \frac{hc}{\lambda} = 10^{-4}$$

$$\frac{n \times 6.63 \times 10^{-34} \times 3 \times 10^8}{10^{-6}} = 10^{-4}$$

$n = 5.02 \times 10^{14} = 50.2 \times 10^{13} \approx 50 \times 10^{13}$

29. **[9]** We know that,

$K.E. = \phi - \phi_0$

Given, $\phi_0 = 3eV = 3 \times 1.6 \times 10^{-19}$ J $= 4.8 \times 10^{-19}$ J ($\because 1ev = 1.6 \times 10^{-19}$ J)

$\lambda = 248nm = 248 \times 10^{-9}$ m

Also,

$$\phi = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{248 \times 10^{-9}}$$

$J = 0.08 \times 10^{-17} J = 8 \times 10^{-19} J$

($\because h = 6.63 \times 10^{-34}$ Js c = 3×10^8 ms^{-1})

Thus, $K.E = 8 \times 10^{-19} - 4.8 \times 10^{-19}$

$= 3.2 \times 10^{-19}$ J

Using, $\lambda = \frac{h}{\sqrt{2K.Em}}$

On substituting values,

$$\lambda = \frac{6.63 \times 10^{-34}}{\sqrt{2 \times 3.2 \times 10^{-19} \times 9.1 \times 10^{-31}}} \text{m}$$

$$= \frac{6.63 \times 10^{-34}}{7.63 \times 10^{-25}} \text{m}$$

$= 0.87 \times 10^{-9}$ m = 8.7 Å = 9 Å

30. **[222]** $E_0 = 4.41 \times 10^{-19}$ J

$\lambda = 300 \times 10^{-9}$ m

$$(K.E.) = E - E_0 = \frac{hc}{\lambda} - E_0$$

$$= \frac{6.63 \times 10^{-34} \text{ Js} \times 3 \times 10^8 \text{ ms}^{-1}}{300 \times 10^{-9} \text{ m}} - 4.41 \times 10^{-19} \text{ J}$$

$= 2.22 \times 10^{-19}$ J = 222×10^{-21} J

31. **(b)** According to the electromagnetic spectrum, balmer series appears in the visible region.

32. **(d)** hν – φ = KE

$$\Rightarrow \left(\frac{hc}{\lambda}\right)_{incident} = KE + \phi$$

$$\left(\frac{hc}{\lambda}\right)_{incident} = KE$$

$$KE = \frac{p^2}{2m} = \frac{hc}{\lambda_{incident}} = \frac{hc}{\lambda} \quad ...(i)$$

$$\Rightarrow \frac{p^2 \times (1.5)^2}{2m} = \frac{hc}{\lambda'} \quad ...(ii)$$

divide (i) and (ii)

$$(1.5)^2 = \frac{\lambda}{\lambda'} \Rightarrow \lambda' = \frac{4\lambda}{9}$$

33. **(c)** K.E = hν-hν$_0$ so (c) is not correct.

34. **(c)** $h\nu = \phi + h\nu_0$

$$\frac{1}{2}mv^2 = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)$$

$$h\nu = \phi + \frac{1}{2}mv^2$$

$$\phi = \frac{6.626 \times 10^{-34} \times 3 \times 10^8}{4000 \times 10^{-10}} - \frac{1}{2} \times 9 \times 10^{-31} \times (6 \times 10^5)^2$$

$\phi = 3.35 \times 10^{-19}$ J ⇒ $\phi = 2.1$ eV

35. **[54]** For hydrogen, the energy of the first Bohr orbit is given by:

$E_1 = -13.6$ eV [Z = 1, n = 1]

For Be^{+3} ion, energy of Ist excited state [Z = 4, n = 2]]

$$\frac{E_H}{E_{He^+}} = \frac{Z_1^2}{n_1^2} \times \frac{n_2^2}{Z_2^2}$$

$$\frac{E_H}{E_{He^+}} = \frac{1}{1} \times \frac{4}{16}$$

$$E_{He^+} = -13.6 \times 4 = -54.4\text{eV}$$

$$|E_{He^+}| = 54.4\text{eV}$$

36. (*d*) The electron in a hydrogen atom's stationary state follows a circular orbit.

37. (*c*) The radius is given by:

$r_n = n^2 a_0$

$\therefore r \propto n^2$

(*a*) $\frac{r_3}{r_1} = \frac{(3)^2}{(1)^2} = 9$

(*b*) $\frac{r_8}{r_4} = \frac{(8)^2}{(4)^2} = \frac{64}{16} = 4$

(*c*) $\frac{r_6}{r_4} = \frac{(6)^2}{(4)^2} = \frac{36}{16} = \frac{9}{4}$

(*d*) $\frac{r_4}{r_2} = \frac{(4)^2}{(2)^2} = \frac{16}{4} = 4$

38. (*a*) As, $r = a_0 \frac{n^2}{Z}$

For Helium ion: Z = 2 and n = 2 (given)

$\therefore r = a_0 \cdot \frac{(2)^2}{2} = 2a_0$

39. (*c*) According to the Bohr model, the radius r_n of the n-th orbit is given by:

$r_n = n^2 a_0$

For the second orbit (n = 2):

$r_2 = 2^2 a_0 = 4a_0$

$n\lambda = 2\pi r_n$

$\lambda = \frac{2\pi r_n}{n}$

$\lambda = \frac{2\pi(4a_0)}{n}$

$= \frac{8\pi a_0}{n}$

40. (*d*) The energy of a hydrogen-like species follows $E_n = -\frac{13.6Z^2}{n^2}$, leading to a parabolic downward curve as Z increases. Option (*d*) correctly represents this trend.

41. (*c*) A. Lyman – U.V
B. Balmer – Visible
C. Paschen – I.R
D. P fund – I.R

42. [10] For 5th excited state ⇒ $n_1 = 6$
For 1st excited state ⇒ $n_2 = 2$
$\Delta n = n_1 - n_2 = 6 - 2 = 4$
Formula for maximum number of spectral lines

$$= \frac{\Delta n(\Delta n + 1)}{2} = \frac{4(4+1)}{2} = 10$$

43. [8] As, $2\pi r_n = n\lambda_d$

Also, $r_n = a_0 \frac{n^2}{Z}$

$2\pi a_0 \frac{n^2}{Z} = n\lambda_d$

For H-atom, Z = 1

$2\pi a_0 \frac{4^2}{1} = 4\lambda_d$

On solving, $\lambda_d = 8\pi a_0$.

44. [22] For H-atom, $n = 1$, $Z = 1$

$V = 2.18 \times 10^6 \times \frac{Z}{n}$

$= 21.8 \times 10^6 \times \frac{1}{1} \approx 22 \times 10^6$

45. [34] Given: $E_2 = -3.4\text{eV}$

$K.E = -E_2 = 3.4\text{ eV} = 34 \times 10^{-4}\text{ eV}$

Hence,

Value of $x = 34 \times 10^{-4}$ eV.

46. (*b*) The formula used for the determination of λ is

$$\frac{1}{\lambda} = R_H\left(\frac{1}{n_i^2} - \frac{1}{n_f^2}\right)$$

where, n_i is initial orbit n_f is final orbit

For H: $\frac{1}{\lambda} = R_H \times 1^2\left(\frac{1}{1^2} - \frac{1}{\infty^2}\right)$ ...(*i*)

$\frac{1}{\lambda_{He^+}} = R_H \times 2^2 \times \left(\frac{1}{4} - \frac{1}{9}\right)$ ...(*ii*)

From (*i*) & (*ii*) $\frac{\lambda_{He^+}}{\lambda} = \frac{9}{5}$

$\lambda_{He^+} = \lambda \times \frac{9}{5} \Rightarrow \lambda_{He^+} = \frac{9\lambda}{5}$

47. (*c*) $Li^{2+}Be^{3+}$

$r_2 = x = k \times \frac{2^2}{3} = \frac{4k}{3}$

$r_3 = y = k \times \frac{3^2}{4}$

$\frac{y}{x} = \frac{9}{4} \times \frac{3}{4} = \frac{27}{16}$

$y = \frac{27}{16}x$

48. (*a*) According to Bohr's model, the angular momentum is quantised and equal to $\frac{nh}{2\pi}$.

$L = \frac{nh}{2\pi}$

Heisenberg uncertainty principle explains orbital concept and it explains we determine the position and momentum the electron simultaneously while in Bohr's model the electrons are assumed to move in a well defined orbits quantised angular momentum.

49. (*d*) The energy of an electron in the orbit of hydrogen atom is calculated by the formula,

$$E_n = \frac{-2.18 \times 10^{-18} Z^2}{n^2}$$

For n = 1

$E_1 = -2.18 \times 10^{-18}$

for n = 3

$$E_3 = \frac{-2.18 \times 10^{-18}}{9} = \frac{1}{9}E_1$$

50. (*c*) From formula of Bohr's radius

$(r_3)_H = \frac{a_0 n^2}{Z} = a_0 \times 3^2 = 9a_0$

By De-Broglie Principle

$2\pi r = n\lambda \Rightarrow 2\pi \times 9a_0 = 3\lambda \Rightarrow \lambda = 6$

51. [492] For first line of paschen series n = 4 and for the second line n = 5

$$\frac{1}{(\lambda_1)_p} = R_H Z^2\left(\frac{1}{9} - \frac{1}{16}\right)$$

$$\frac{1}{(\lambda_2)_p} = R_H Z^2\left(\frac{1}{9} - \frac{1}{25}\right)$$

$$\frac{(\lambda_2)_p}{(\lambda_1)_p} = \frac{\frac{7}{16 \times 9}}{\frac{16}{25 \times 9}} = \frac{25 \times 7}{16 \times 16}$$

$$(\lambda_2)_p = \frac{25 \times 7}{16 \times 16} \times 720$$

$(\lambda_2)_p = 492$ nm

52. [270] $r \propto \frac{n^2}{Z}$

Given: $r_H = 0.6$ Å

n = 3 (For 3rd orbit)

z = 2

$r_{He^+} = r_H \times \frac{n^2}{Z}$

$r_{He^+} = 0.6 \times \frac{(3)^2}{2} = 2.7$Å

$r_{He^+} = 270$ pm

53. [1] $\Delta E = R_H Z^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

For Li^{2+}, Z = 3, $n_1 = n$, $n_2 = n + 1$

Given:

ΔE : 1.47×10^{-17} J, $R_H = 2.18 \times 10^{-18}$

1.47×10^{-17}

$$= 2.18 \times 10^{-18} \times 9\left(\frac{1}{n^2} - \frac{1}{(n+1)^2}\right)$$

$$\frac{1.47}{1.96} = \frac{3}{4} = \frac{1}{n^2} - \frac{1}{(n+1)^2}$$

On solving, n = 1

54. (*b*) Radius of Bohr's orbit for hydrogen, $R_n = 0.529\text{Å} \times n^2$

For third orbit $(R_3) = 0.529\text{Å} \times 9 = r_3$

Fourth orbit $(R_4) = 0.529\text{Å} \times 16 = r_4$

$\therefore \frac{0.529\text{Å} \times 9}{0529\text{Å} \times 16} = \frac{r_3}{r_4}, r_4 = \frac{16r_3}{9}$

55. [10] For single H- atom, maximum number of spectral lines $\frac{n(n-1)}{2} \Rightarrow \frac{5(5-1)}{2} = 10$.

n = orbit number of excited electron.

56. [2] $\lambda = \frac{h}{\sqrt{2mE}}$ Here,

E = Kinetic Energy

$E = \frac{h^2}{2m\lambda^2}$

$$= \frac{(6.626 \times 10^{-34})^2}{2 \times 9.1 \times 10^{-31} \times (3.3 \times 10^{-10})^2}$$

$= 2.215 \times 10^{-18}$

$E_{absorbed} = E_{required} + K.E$

$\frac{E_{absorbed}}{E_{required}} = 1 + \frac{K.E}{E_{required}}$

$$= 1 + \frac{2.215 \times 10^{-18}}{13.6 \times 1.602 \times 10^{-19}} = 2.016 \approx 2$$

57. [*] Bohr's model is only applicable for H-like species. Hence, the value of x can't be determined.

58. (*d*) Bohr's theory is applicable only for the line spectrum of single electron species, but Li^+ has two electrons.
Bohr's theory fails to explain splitting of spectral lines in presence of magnetic field i.e. Zeeman effect.

59. (*a*) According to Bohr's model, velocity of an electron increases with atomic number (z) and decreases with number of shell (n) that is, $V_e \propto \frac{Z}{n}$ (z = Atomic number and n = number of shell / principal quantum number)

60. (*a*) According to Bohr's theory,

$K.E. = 13.6 \times \frac{Z^2}{n^2}$

$v = 2.18 \times 10^6 \times \frac{Z}{n}$

$F = \frac{kq_1q_2}{r^2} = \frac{kZe^2}{r^2}\left(r \propto \frac{n^2}{Z}\right)$

So, according to the above expression,

$F \propto \frac{Z^3}{n^4}$

Hence, (A) and (D) are correct.

61. [3155]

$K.E = \frac{n^2h^2}{8\pi^2 mr^2}$ (Bohr's kinetic energy)

for n = 2, we have

$K.E = \frac{4h^2}{8\pi^2 m(4a_0)^2}$ $(\because r = 4a_0)$

$= \left(\frac{4}{8\pi^2 \times 16}\right)\frac{h^2}{ma_0^2}$

$K.E = \frac{1}{32\pi^2}\frac{h^2}{ma_0^2}$ $(\because r = 4a_0)$

On comparing with $\frac{h^2}{xma_0^2}$ (given)

$x = 32\pi^2 = 315.50 \Rightarrow 10x = 3155$

62. (*c*) Hydrogen spectrum is explained by Bohr's atomic model and from Bohr's atomic model, uncertainity principle can't be explained.

63. (*c*) The wave length/wave number of light emitted/absorbed is calculated by Rydberg's formula. It is expressed as,

$\bar{v} = \frac{1}{\lambda} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

For H atom, z = 1

$\bar{v} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

For Balmer series: $n_1 = 2$

If $n_2 = 3$ $\therefore \frac{1}{\lambda} = RZ^2\left(\frac{1}{4} - \frac{1}{9}\right)$

$\frac{1}{\lambda} = R\frac{5}{36}$

$\lambda_{max} = \frac{36}{5R}$

64. (*a*) As, $r = a_0 \times \frac{n^2}{Z}$

For IInd Bohr orbit of Li^{2+} (n = 2, Z = 3)

$r = \frac{a_0 \times 4}{3} = \frac{4a_0}{3}$

65. (*c*) For H-atom;
For Lyman series: $n_1 = 1$ & $n_2 = \infty$

$\frac{1}{\lambda_H} = R_H\left[\frac{1}{1} - \frac{1}{\infty}\right]$ So, $\lambda_1 = \frac{1}{R_H}$

For He^+ ion;
For Balmer series: $n_1 = 2$ & $n_2 = 3$

$\frac{1}{\lambda_{He^+}} = R_H \times Z^2\left[\frac{1}{4} - \frac{1}{9}\right]$

$\frac{1}{\lambda_{He^+}} = R_H \times 4 \times \frac{5}{36}$

$\frac{1}{\lambda_{He^+}} = \frac{5}{9}R_H = \left(\frac{5}{9}\right)\frac{1}{\lambda_1} \Rightarrow (\lambda_{He^+}) = \frac{9}{5}\lambda_1$

66. (*c*) $E = -13.6\frac{Z^2}{n^2}$eV

$E_{He^+} = -13.6\frac{4}{9} = -6.04$ eV

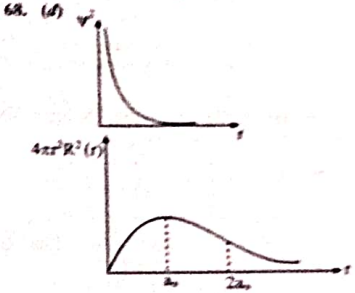
67. (*b*) $\frac{\frac{1}{\lambda_2} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)Z^2}{\frac{1}{\lambda_1} = R_H\left(\frac{1}{m_1^2} - \frac{1}{m_2^2}\right)Z^2}$

as for shortest wavelengths both n_2 and m_2 are ∞

$\therefore \frac{\lambda_2}{\lambda_1} = \frac{9}{1} = \frac{m_2^2}{n_2^2}$

Now if $m_2 = 3$ & $n_2 = 1$ it will justify the statement hence Lyman and Paschen.

68. (*d*)



69. (*d*) For emission line
$n_f < n_i$

$\therefore \bar{v} = RZ^2\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right] = R\left[\frac{1}{8^2} - \frac{1}{n^2}\right]$

or, $\bar{v} = R_H\left(\frac{1}{64} - \frac{1}{n^2}\right) = \frac{R_H}{64} - \frac{R_H}{n^2}$

$\bar{v} = -R_H\left(\frac{1}{n^2}\right) + \frac{R_H}{64}$

$\therefore y = mx + c$

Slope $= -R_H$

70. (*d*) For Lyman

$\bar{V}_{max} = R_H\left(\frac{1}{1^2} - \frac{1}{\infty^2}\right) = R_H$

$\bar{V}_{min} = R_H\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = \frac{3}{4}R_H$

$\Delta\bar{V}_{Lyman} = \frac{R_H}{4}$

For Balmer

$\bar{V}_{max} = R_H\left(\frac{1}{2^2} - \frac{1}{\infty^2}\right) = \frac{R_H}{4}$

$\bar{V}_{min} = R_H\left(\frac{1}{2^2} - \frac{1}{3^2}\right) = \frac{5}{36}R_H$

$\Delta\bar{V}_{Balmer} = \frac{R_H}{4} - \frac{5R_H}{36} = \frac{4R_H}{36} = \frac{R_H}{9}$

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$$\frac{\Delta x_{cm}}{\Delta x_{micro}} = \frac{R_{cm}\lambda_{cm}}{R_{micro}\lambda_{micro}} = \frac{9}{4}$$

76. (ab) [c] Given: $\Delta V = 100$ V. λ is in nanometer region, therefore Planck's

72. (ab) $2\pi r = n\lambda$

$$\lambda = \frac{2\pi r}{n} = \frac{2\pi \times \frac{a_0}{2}}{n \times 2} = 2\pi\frac{a_0}{4}$$

$\lambda = 1.5\pi a_0$

$\therefore 2\pi\frac{a_0}{4} = 1.5\pi a_0$

$\therefore \frac{a_0}{4} = \frac{1.5}{2} = 0.75$

73. (ab) (A) Correct. It defines the orbital shape (s, p, d, f).

(B) Correct. The nodal diagram of the $2p_x$ orbital is shown in the yz plane.

(C) Incorrect. + and − signs in wave function represent phases, not charge.

(D) Incorrect. The wave function of $2p_x$ orbital is zero along the yz plane, not the entire xy plane.

74. (a) Both Statement I and Statement II are true.

75. (a) $\lambda = \frac{h}{P}\left[\lambda \propto \frac{1}{P}\right]$

$\Rightarrow \lambda p = h$ (constant)

Hence, the plot can be represented as a rectangular hyperbola.

76. [*] de Broglie wavelength,

$\lambda = \frac{h}{mv}$

Multiplying with 'v' in both numerator and denominator

$\lambda = \frac{hv}{mv^2}$

$\frac{mv^2}{h} = \frac{v}{\lambda} = \nu$ (frequency)

given $\frac{1}{2}mv^2 = 2.08 \times 10^{-18}$ J

$h = 6.6 \times 10^{-34}$

$\nu = \frac{4.16 \times 10^{-18}}{6.6 \times 10^{-34}} = 662.62 \times 10^{14}$ Hz

$= 66.1 \times 10^{14}$ Hz

NTA ans → [658]

PW ans → [661]

77. [58] [illegible] uncertainty principle,

$$m\Delta V \cdot \Delta x = \frac{h}{4\pi}$$

Given: $m = 9.1 \times 10^{-31}$ kg

$h = 6.626 \times 10^{-34}$ Js

$\Delta x = 10^{-13}$ m

$$\Delta V = \frac{6.626 \times 10^{-34}}{9.1 \times 10^{-31} \times 10^{-13} \times 4 \times 3.14}$$

On solving,

$\Delta V = 57.97 \times 10^{9}$ m/sec

78. (d) At node $\Psi_{2s} = 0$

$\therefore 2 - \frac{r_0}{a_0} = 0$

$\therefore r_0 = 2a_0$

Hence, option (d) is the correct answer.

79. [22] $\Delta V = 2.4 \times 10^{-26}$ m/sec

And $\Delta x = 10^{-7}$ m

According to Heisenberg's uncertainty principle,

$$\Delta x \cdot \Delta p = \frac{h}{4\pi}$$

$$\Delta x \cdot m\Delta v = \frac{h}{4\pi}$$

$$\therefore m = \frac{h}{4\pi \times \Delta v \times \Delta x} = \frac{6.626 \times 10^{-34}}{4 \times 3.14 \times 2.4 \times 10^{-26} \times 10^{-7}}$$

$$= \frac{6.626 \times 10^{-1}}{30.144}$$

$m = 22$

80. [1759] $X_s = X_e$

$\Rightarrow M_s V_s = M_e V_e$

$$\Rightarrow \frac{V_s}{V_e} = \frac{M_e}{M_s} = \frac{1.6 \times 10^{-27}}{9.1 \times 10^{-31}} \approx 1758.24$$

81. [548] According to Heisenberg's uncertainty principle, we have

$$\Delta x \times \Delta p = \frac{h}{4\pi}$$

$$\text{Or } \Delta x \times \Delta v = \frac{h}{4\pi \times m}$$

Given: $h = 6.63 \times 10^{-34}$ Js, $m = 9.1 \times 10^{-31}$ kg

$$\therefore \Delta v = \frac{6.63 \times 10^{-34}}{4 \times 3.14 \times 2 \times 52.9 \times 10^{-12} \times 9.1 \times 10^{-31}}$$

$= 548273$ m/s

Or $\Delta v = 548$ km sec^{-1}

82. [58] By using Heisenberg uncertainty principle:

$$\Delta x \cdot \Delta p = \frac{h}{4\pi}$$

$$\Delta x \cdot \Delta v = \frac{h}{4\pi m}$$

$$\Delta v = 5 \times 10^{6} \times \frac{0.02}{100} = 5 \times 2 \times 10^{2} = 1000 \text{ m/s}$$

$= 5.8 \times 10^{9}$ m $= 58 \times 10^{9}$ m

83. (d) As, $n = 4$ & $r = a_0\frac{n^2}{Z}$

$\therefore 2\pi a_0 \frac{n^2}{Z} = n\lambda$ ($\because 2\pi r = n\lambda$)

$2\pi \frac{4^2 a_0}{1} = 4\lambda \Rightarrow \lambda = 8\pi a_0$.

84. (d) $\lambda = \frac{h}{mv}$

According to Einstein's theory of photoelectric effect:

$h\nu = h\nu_0 + KE$

$h\nu = h\nu_0 + \frac{1}{2}mv^2$

$2h(\nu - \nu_0) = mv^2$

$\frac{2h(\nu - \nu_0)}{m} = v^2$

$v \propto (\nu - \nu_0)^{1/2}$

$\lambda \propto \frac{h}{m(\nu - \nu_0)^{1/2}}$

$\lambda \propto \frac{1}{(\nu - \nu_0)^{1/2}}$

85. (b) Fluorine (atomic number 9) has electron configuration of $1s^2 2s^2 2p^5$

[↑↓] [↑↓] [↑↓↑↓↑]

(A) 5 electrons can be up-spin $\left[m_s = \frac{1}{2}\right]$ and 4 electrons can be down $\left[m_s = -\frac{1}{2}\right]$

(B) Fluorine has unpaired electrons in any of p_x, p_y, and p_z orbitals, so it is incorrect.

(C) Last electron is in 2 p subshell, $n = 2$, $\ell = 1$

(D) Angular node for s-orbital = 0, of each p-orbital = 1

The total number of angular nodes in p orbitals is 3, not 1, so this statement is incorrect.

86. (c) The electron configuration of Chromium (Cr) is $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1$.

$\ell = 1$

$\ell = 1$ corresponds to the p orbitals, which contain 12 electrons (2 in 2p, 6 in 3p)

$\ell = 2$

$\ell = 2$ corresponds to the d orbitals, which contain 5 electrons in the 3d subshell.

87. (d) Energy of electron is maximum at infinite distance from nucleus.

88. (d) The formula for orbital angular momentum is given by:

$$L = \sqrt{\ell(\ell+1)} \times \frac{h}{2\pi}$$

Where: l is the azimuthal quantum number and h is Planck's constant

For 2s orbital: $l = 0$,

Orbital angular momentum = 0

For 2p orbital : $l = 1$

Orbital angular momentum

$= \sqrt{2}(h/2\pi)$

89. (d) As $2p_x$ and $2p_y$ are degenerate orbitals, so no spectral line will be observed for $2p_x$ to $2p_y$ transition.

90. (b) For a given shell, the total number of allowed orbital is given by n^2

$n \Rightarrow$ principal quantum number.

Consider M – shell, $n = 3$

So, number of allowed orbital will be 9.

It can be seen as,

[ ] [ ][ ][ ] [ ][ ][ ][ ][ ]

3s 3p 3d

So, statement-I is correct.

For any subshell, the spatial or magnetic quantum number is given by $2l + 1$ or $-l$ to $+l$ values including zero.

So, statement-II is correct.

91. (b) In a multi-electron atom, the orbitals (D) $n = 3$, $l = 2$, $m = 1$ and (E) $n = 3$, $l = 2$, $m = 0$ described by the three quantum numbers will have the same energy in the absence of magnetic and electric fields.

D and E are 3d orbital.

92. (d) The energy of an electron in a hydrogen atom is determined solely by the principal quantum number. Thus, the energy of the orbitals in hydrogen atom increases as follows :

$1s < 2s = 2p < 3s = 3p = 3d < 4s = 4p = 4d = 4f$

93. (d) For H-atoms, orbitals in the shell are degenerate, meaning energy depends only on the value of 'n'.

$\therefore E_{3p_x} = E_{3d_{z^2-y^2}} = E_{3s}$

94. [16] For $n = 4$ we have

	4s	4p	4d	4f
Total e⁻	2	6	10	14
Total no.of electron with "S" = $+\frac{1}{2}$	1	3	5	7

95. (a) Electronic configuration of Rb = [Kr]5s1

$n = 5$, $l = 0$, $m = 0$, $s = +½$ or $-½$

96. (a) In hydrogen 3s, 3p and 3d orbitals have same energy. So, statement I is true and II is false.

97. (b) $_{19}K \rightarrow 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^1$

The outermost orbital of potassium is the 4s orbital.

$n = 4$, $l = 0$, $m_l = 0$, $s = \pm½$

98. (a) For 3p : $n = 3$, $\ell = 1$

Number of radial node = $n - \ell - 1$

$= 3 - 1 - 1 = 1$

99. [4]

n = 4, [ ] [ ][ ][ ] [ ][ ][ ][ ][ ] [ ][ ][ ][ ][ ][ ]

4s 4p 4d 4f

$m_l \Rightarrow$ 1 1 1 1

So, Maximum number or orbitals are 4.

100. [6] $n = 4$

ℓ	m_l
0	0
1	−1, 0, +1
2	−2, −1, 0, +1, +2,
3	−3, −2, −1, 0, 1, 2, 3

So, number of orbital associated with $n = 4$, $|m_l| = 1$ are 6

Now, each orbital contain one e^- with $m_s = -\frac{1}{2}$

Hence, total number of electrons with the above quantum number are 6.

101. (d) The energy level can be determined by comparing $(n + \ell)$ values. More the $(n + \ell)$ value, more will the energy

(A) $n = 4$, $\ell = 1 \Rightarrow (n + \ell) = 5$

(B) $n = 4$, $\ell = 2 \Rightarrow (n + \ell) = 6$

(C) $n = 3$, $\ell = 1 \Rightarrow (n + \ell) = 4$

(D) $n = 3$, $\ell = 2 \Rightarrow (n + \ell) = 5$

(E) $n = 4$, $\ell = 0 \Rightarrow (n + \ell) = 4$

For the same value of $(n + \ell)$, the orbital with more value of n, will have more energy.

Hence, the correct order is:-

(B) > (A) > (D) > (E) > (C)

102. (b) The maximum number of electrons that can be accommodated in shell with $n = 4$ can be calculated using the formula $2n^2$

Thus, Number of electrons = $2(4)^2 = 32$

103. (b) (A) $n = 3$; $l = 0$; $m = 0$; 3s orbital

(B) $n = 4$; $l = 0$; $m = 0$; 4s orbital

(C) $n = 3$; $l = 1$; $m = 0$; 3p orbital

(D) $n = 3$; $l = 2$; $m = 0$; 3d orbital

Higher the value of $(n + l)$, higher will be the energy. For the same values of $(n + l)$, higher value of n will be higher in energy.

104. [5.00] p_x, p_y, p_z, d_{z^2} & $d_{z^2-y^2}$ are axial orbitals.

105. [3] Radial node is calculated by the formula $n - \ell - 1$.

For 7s ⇒ R.N = 7 − 0 − 1 = 6

For 7p ⇒ R.N = 7 − 1 − 1 = 5

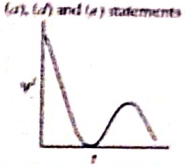
For 6s ⇒ R.N = 6 − 0 − 1 = 5

For 8p ⇒ R.N = 8 − 1 − 1 = 6

For 8d ⇒ R.N = 8 − 2 − 1 = 5

For 7p, 6s and 8d the value of radial node is same i.e. 5.

106. (c) (a), (d) and (e) statements are correct



For 2s orbital, the probability density first decreases and then increases. Angular nodes for p and d-orbitals is 1 and 2.

At any distance from nucleus the probability density of finding electron is never zero and it always have some finite value.

107. [0] Orbital angular momentum $= \sqrt{l(l+1)}\frac{h}{2\pi}$

On comparing the formula of orbital angular momentum given above with the value given in question, we get $x = \sqrt{l(l+1)}$

The value of l for $s = 0$

Therefore, the value of x will be zero.

108. (a) In 4d orbital , $n = 4$ and $\ell = 2$

Radial nodes = $n - \ell - 1$, $4 - 2 - 1 = 1$

And angular nodes , $\ell = 2$

109. (a) For (A) $n + \ell = 3$

(B) $n + \ell = 4$

(C) $n + \ell = 4$

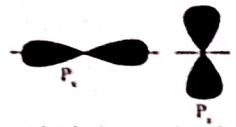
(D) $n + \ell = 5$

Energy of the orbitals is directly proportional to the $(n + \ell)$ value. Higher $(n + \ell)$ valued orbital will have higher energy. If $n + \ell$ is same, then higher the value of n, higher is the energy.

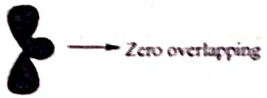
(∴ D > B > C > A)

110. (d) An atomic orbital is characterised by three quantum numbers: n, l and m.

111. (a)



Zero overlapping is present due to improper orientation



112. (b) Degenerate orbitals must have same energy.

∴ Orbitals with same values of n and l are degenerate orbitals.

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113. (*c*) The principal quantum number, n can have values = 1, 2, 3, ...
The azimuthal quantum number *l* can have values = 0, 1, 2 ..... n – 1
The magnetic quantum number can have values = 2*l* + 1.
The values of spin quantum number, m_s are $\pm\frac{1}{2}$.
The number of orbitals for particular value of *l* are 2*l* + 1, thus for *l* = 5, no. of orbitals = (2 × 5 + 1) = 11.

114. (*b*) For 2s, the number of radial nodes = n – ℓ – 1 = 2 – 0 – 1 = 1, and $\psi^2(r)$ will always be positive. Hence, option (*b*) is correct, since it has one radial node and it is +ve.

115. (*c*) Value of n & l can't be same. *l* is always less than n.

116. (*b*) Rule of (n + ℓ) determines the sequence of sub energy level. The one with more (n + ℓ) value has more energy. And in case if (n + ℓ) value is same, then the one with more 'n' value has more energy.

117. (*a*) Energy of orbitals in same subshell decrease with an increase in the atomic number.

118. [2] Conditions: For a valid set of quantum numbers, following conditions needs to be satisfied.
l = 0 to n – 1, m_l = –l to + l
A. n = 3 l = 3 m_l = –3 is incorrect as l can not be equal to n.
B. n = 3 l = 2 m_l = –2 is correct set.
C. n = 2 l = 1 m_l = +1 is correct set
D. n = 2 l = 2 m_l = +2 is incorrect set as l can not be equal to n.
So, B and C are the correct set of quantum numbers.

119. (*a*) Number of radial nodes of 3s orbital are:
= n – ℓ – 1 = 3 – 0 – 1 = 2

120. (*a*) Total Node = n – 1
Radial Node = n-ℓ-1
Angular Node : ℓ
Here, ℓ is Azimuthal Quantum number
Here, Angular node = 0
⇒ ℓ = 0 i.e s orbital
Radial nodes = 2
⇒ n-ℓ-1 = 2
n-0-1 = 2 ⇒ n = 3
Hence, orbital is 3s

121. (*b*) Radial node = n – ℓ – 1 for 5d, 5 – 2 – 1 = 2
Angular node = ℓ for d-orbital, ℓ = 2

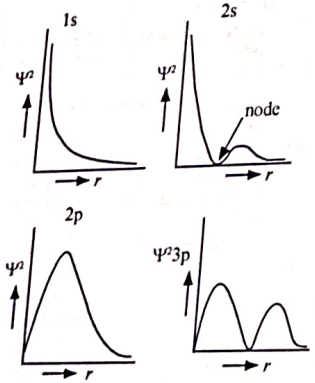
122. [0] For n = 4, *l* = 0, 1, 2, 3
For *l* = 3 and m = –3
Radial nodes = (n – *l* – 1) = (4 – 3 – 1) = 0

123. [3] When n = 5 and m_l = +2, also ℓ can have values from 0 to (n – 1) and m_l = –ℓ to +ℓ
ℓ = 0, m_l = 0
ℓ = 1 m_l = –1, 0, +1
ℓ = 2 m_l = –2, –1, 0, +1, (+2)
ℓ = 3m_l = –3, –2, –1, 0, +1, (+2), +3
ℓ = 4m_l = –4, –3, –2, –1, 0, +1, (+2), +3, +4
Thus, the number of orbital with n = 5 and m_l = +2 are 3.

124. (*a*) For a principal quantum number n = 4, possible value of *l* = 0, 1, 2, 3. Because for any n value, *l* = 0 to n – 1, only *l* = 2 & *l* = 3 can have m = – 2. So, possible subshells are 2. Because for any value of *l*, m will have values from –*l* to + *l*.

125. (*c*) For n = 1, *l* = 0, 1, 2
For n = 2, *l* will be 0, 1, 2, 3
Electronic configuration of element is:
1s 1p 1d 2s 2p 2d 2f
For atomic number 13:
$1s^2\ 1p^6\ 1d^5$ (half-filled)

126. (*a*) Probability density plots for 1s, 2s, 2p and 3p orbitals are:



From the given graph answer is (*a*)

127. (*d*) For a principal quantum number there will be (n – 1) values of *l* there if n = 5, *l* = 5-1 = 4 values
For any value of *l*, there will be –*l* "m values".
n = 5 m → – *l* to + *l*
l = n – 1 → 0 → 0 = 4
→ 1 → –1, 0, 1 →
→ 2 → –2, –1, 0, 1, 2
(0, 1, 2, 3)
→ 3 → –3, –2, –1, 0, 1, 2
→ 4 → – 4, –3, –2, –1, 0, 1, 2, 3, 4
Total 25 orbitals are possible.

128. (*c*) Figures a, b and d are according quantum theory but figure c belongs kinetic theory of gases.

129. (*c*) According to Aufbau's principal electrons are filled in increasing energy atomic orbitals. For sixth period electrons the correct order is:
6s < 4f < 5d < 6p

130. (*b*) For isoelectronic species, the size compared by nuclear charge.

131. (*c*) The electron configuration is $4f^{14}\ 5d^1\ 6s^2$

132. (*d*) Graph of $|\psi|^2$ v/s r touches r axis point so it has one radial node and since at r = 0, it has some value so it should for 's' orbital.
∴ n – *l* – 1 = 1 where *l* = 0 ⇒ n – 1
∴ n = 2 ⇒ '2s' orbital

133. (*b*) $P(x) = 4\pi x^2 \times [\psi_x]^2$
Probability will be maximum at A and

134. (*a*) K, 2s feels more attraction fr nucleus so It has less energy.

135. (*c*) (A) $mvr = \frac{nh}{2\pi}$
As n increases, angular momentum increases.
(C) Angular momentum $= \frac{nh}{2\pi}$

136. (*b*) According to (n + ℓ) rule : 3p < < 4p < 4d

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1. (*d*) Rutherford's experiment, which established the nuclear model of the atom, used a beam of helium nuclei (α-particles), which impinged on a gold foil (of thickness 100 nm) and got scattered. The gold foil was surrounded by a ZnS fluorescent screen. Wherever alpha particles strike the screen, a tiny flash of light is produced at that point. α-particles are called a helium nucleus. Hence, the correct option is (*d*)

2. (*b*) According to the Rutherford's model, the electrons revolve around positively charged core or in other words, negatively charged electrons occupy space around the nucleus and the atom is electrically neutral.

3. (*b*) The nucleus is present inside the atom. So the size of an atom is more than that of the size of an atomic nucleus. Radius of an atom is about 10^{-8} cm and the radius of atomic nucleus is about 10^{-13} cm.

4. (*d*) Increasing order (lowest first) for the values of e/m (charge / mass) for electron (e), proton (p), neutron (n) and α-particle (a) is n, α, p, e

e/m for neutron $= \frac{0}{1} = 0$

e/m for alpha particle $= \frac{2}{4} = 0.5$

e/m for proton $= \frac{1}{1} = 1$

e/m for electron $= \frac{1}{\left(\frac{1}{1850}\right)} = 1850$

Note: e is the charge of the particle, m is the mass of a particle and the mass of an electron is $\frac{1}{1850}$ times the mass of a proton.
Hence, the correct option is (*d*).

5. (*a*) Rutherford's discovery of the nucleus of an atom was based on the alpha scattering experiment. So that experiment was also related to the size of the nucleus

6. (*c*) Rutherford's experiment on scattering of α-particles showed for the first time that the atom has a nucleus. He observed that the positively charged α-particles were repelled and deflected by the positive charges in the atom. Rutherford named this positively charged portion of atom as nucleus.

7. (*a, b*) The atom is made up of a central core which is called a nucleus. The nucleus consists of protons that are positively charged and neutrons that are neutral. The electrons revolve around this central core in the orbits.

8. (*a*)

	Number of Proton	Number of Neutrons
Hydrogen	1	0
Deuterium	1	1
Tritium	1	2

Hydrogen has three isotopes.
The sum of the number of protons is 1 + 1 + 1 = 3
The sum of the number of neutrons is 0 + 1 + 2 = 3 The sum of the number of neutrons and proton in the isotope of hydrogen is 3 + 3 = 6

9. (*a, c*) From Rutherford alpha scattering experiment it concluded that atom has large vacant space as most of the alpha particle go straight without any deflection. Also, they are heavier than electrons, hence can not attracted by them and go straight.

10. (*a, c*) Elements have non integral atomic masses because isotopes have different masses and occur in nature in different proportions.
E.g.
Cl; Z = 17 and A = 35 and 37.
They are present in the ratio 3:1.
$\therefore \frac{3\times35+1\times37}{4} = 35.5$

11. (*b, d*) Two nuclides are isotones if they have the same neutron number but different proton number. For example, boron-12 and carbon-13 nuclei both contain 7 neutrons, and so are isotones.
So, isotone of Ge (atomic number 32, mass number 76) is Se (atomic number 34 and mass number 78). The number of neutrons of Ge here is 76-32 = 44, now in Se here, 78-34 = 44 neutrons, due to the same number of neutrons, these are isotones.
The number of neutrons in $^{77}_{33}As$ and $^{78}_{34}Se$ are 44. So, they are isotones of $^{76}_{32}Ge$

12. (Isobars)

13. (1.66×10^{-27} kg) Molecular weight of Hydrogen is 1 amu as it has only 1 proton and no neutron.
Atomic mass = Number of protons + Number of neutrons
∴ Atomic mass of hydrogen = 1
To convert it into Kg multiply by 1.66×10^{-27} Kg
→ 1amu × 1.66×10^{-27} Kg = 1.66×10^{-27} Kg

14. (Neutrons) Isotopes are defined as the atoms of the same element having the same atomic number but different mass numbers. The number of protons in all the atoms of a particular element is same, therefore to have different mass numbers, isotopes contain different number of neutrons.

15. (TRUE)
As the mass of alpha particle is high, it show less deflection than beta particles

16. (*b*) Using Planck's quantum theory, Neils Bohr hypothesised the atom's stability in 1913 and explained the reason of spectral lines. Bohr proposed that the energy of electrons in an atom be quantized, and he described the structure of atoms using quantum theory.

17. (*d*) E = hν relates to photon both as wave motion and a stream of particles.
However, interference and diffraction relate to only wave nature.

18. (*c*) X-rays are not deflected by electric and magnetic fields as they are electromagnetic waves that are chargeless and massless.

19. (*d*) E = hc/λ.
$\frac{E_1}{E_2} = \frac{\lambda_2}{\lambda_1} = \frac{4000}{2000} = \frac{2}{1}$ ratio of energy of photon

20. (*b*) Electromagnetic radiation with maximum wavelength is radio-waves. It is least energy radiation.
Electromagnetic radiation with minimum wavelength is X-rays. It is the most energetic form of radiation.

21. (*b*) The Bohr model failed to describe the spectra of atoms or ions with two or more electrons, because Bohr's model is valid to atom or ion having only one electron such as H, He^+, Li^{++}, Be^{+++}, etc.
Hence, the correct option is (*b*).

22. [5] Atomic mass of helium and neon is 4 amu and 20 amu
m_{He} = 4 amu and m_{Ne} = 20 amu
T_{He} = – 73°C = (273 + (–73))K = 200 K
T_{Ne} = 727°C = (273 + 727)K = 1000 K
As we know that the de Broglie wavelength of gas molecules is given by-
$\lambda = \frac{h}{\sqrt{3mkT}}$
where, k = Boltzmann constant

$\lambda_{He} = M\lambda_{Ne}$ (Given)

$$\Rightarrow \frac{h}{\sqrt{3\times4\times k\times200}} = M\frac{h}{\sqrt{3\times20\times k\times1000}}$$

$\Rightarrow M = \sqrt{25} = 5$

Hence, the value of the de Broglie wavelength of helium is 5 times the de Broglie wavelength of neon.

23. [4] $E = \frac{hc}{\lambda} = \frac{6.6\times10^{-34}\times3\times10^{8}}{300\times10^{-9}}$ J

$$E(\text{in eV}) = \frac{6.6\times10^{-34}\times3\times10^{8}}{300\times10^{-9}\times1.6\times10^{-19}} = 4.125\text{eV}$$

Photoelectric effect is removal of electrons from metal surface, when light is incident on it.

For the photoelectric effect, energy of a photon must be greater than the work function of the metal.

So, the number of metals showing photo-electric effects will be (4) i.e., Li, Na, K, Mg

24. (Photons) Photons are light radiations that have discrete amounts of energy.

25. (FALSE)

The given wavelength here corresponds to IR waves 10^{-4} cm to 10^{-5} cm.

For gamma rays the wavelength range is very small of order 10^{-14} cm to 10^{-10}.

26. The shortest wavelength transition in the Balmer series corresponds to the transition

$n_1 = 2, n_2 = \infty$

For hydrogen spectrum,

Wave number, v^{-} or $\frac{1}{\lambda} = R_H\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

Putting the values and we get

$$v = \frac{1}{\lambda} = R_H Z^2\left[\frac{1}{2^2} - \frac{1}{\infty}\right]$$

$$v = \frac{109677}{4}\text{cm}^{-1}$$

$v = 27419.5\ \text{cm}^{-1}$

27. Energy given to I_2 molecule $= \frac{hc}{\lambda}$

$$= \frac{6.626\times10^{-34}\times3.0\times10^{8}}{4500\times10^{-10}} = 4.417\times10^{-19}\text{J}$$

Also, energy used for breaking up of I_2 molecule is

$$\frac{B.E}{N_A} = \frac{240\times10^{3}}{6.023\times10^{23}} = 3.984\times10^{-19}\text{J}$$

$\because$ Energy used in imparting kinetic energy to two iodine atoms,

$= (4.417 - 3.984)\times10^{-19}$ J

$\therefore$ K.E./iodine atom

$$\frac{(4.417-3.984)}{2}\times10^{-19} = 0.216\times10^{-19}\text{J/atom}$$

28. $\lambda_H = \lambda_{He^+}$

$$\therefore R_H Z_H^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] = R_H Z_{He^+}^2\left[\frac{1}{2^2} - \frac{1}{4^2}\right]$$

Where R_H = Rydberg constant

n_1, n_2 = Principal quantum numbers

Z = Atomic number (1 for H, 2 for He)

$$\left[1\times\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] = 4\times\left(\frac{1}{4} - \frac{1}{16}\right)\right]$$

$$\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] = 4\times\frac{4-1}{16}$$

$n_1 = 1$, then $n_2 = 2, 3\ldots$

For the first line, $n_2 = 2, n_1 = 1$

$$\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] = \frac{1}{1} - \frac{1}{4} = \frac{3}{4}$$

Hence, transition $n_2 = 2$ to $n_1 = 1$ will give spectrum of the wavelength as that of the Balmer transition, $n_2 = 4$ to $n_1 = 2$ in He^+.

29. (*b*) In n^{th} Bohr's orbit, the K.E. of an electron is given by:

K.E. $= 13.6\frac{Z^2}{n^2}$ eV/atom, where z is the atomic number and n is the orbit.

$\Rightarrow$ K.E. $\times \frac{z^2}{n^2}$

For n = 1 (H-atom), K.E. $\propto \frac{1^2}{1^2} = 1$

n = 1 (He^+ ion), K.E. $\propto \frac{2^2}{1^2} = 4$

n = 2 (He^+ ion), K.E. $\propto \frac{2^2}{2^2} = 1$

n = 2 (Li^{2+} ion), K.E. $\propto \frac{3^2}{2^2} = \frac{9}{4}$

Hence, it is highest for $\rightarrow$ n = 1 of He^+ ion.

30. (*c*) K.E. $= \frac{1}{2}mv^2$ ...(1)

$mvr = \frac{nh}{2\pi} \rightarrow$ (Bohr's Model)

$$(mv)^2 = \frac{n^2h^2}{4\pi^2r^2}$$

$$mv^2 = \frac{1}{m}\times\frac{n^2h^2}{4\pi^2r^2} \quad ...(2)$$

Put (2) in (1)

$$\text{K.E} \Rightarrow \frac{1}{2}\times\frac{1}{m}\times\frac{n^2h^2}{4\pi^2r^2}$$

Now, $n_0 = 2, r_1 = a_0, r_2 = a_0\times(2)^2 = 4a_0$.

$$\text{K.E.} \Rightarrow \frac{1}{2}\times\frac{2^2h^2}{4\pi^2(4a_0)^2m}$$

$$\Rightarrow \frac{h^2}{32\pi^2a_0^2m}$$

31. (*b*) As we know that,

$$r = r_0\frac{n^2}{Z}$$

where,

r_0 = radius of 1st Bohr's orbit of hydrogen atom = 0.529Å

For $r = r_0$,

$$\frac{n^2}{Z} = 1$$

$\Rightarrow n^2 = Z$ ...(1)

$\because$ For n = 2

Z = 4, which satisfies equation (1).

Hence, n = 2, Be^{+3} will have the same radius of 1st Bohr's orbit of a hydrogen atom.

32. (*a*) Since we know that the energy of electron in H atom

$$E_n = -\frac{13.6}{n^2}.\text{eV where, } n = 1, 2, 3,\ldots$$

For the first excited state (n=2),

$$E_2 = -\frac{13.6}{4} = -3.4\text{ eV}$$

For second excited state (n=3)

$$E_3 = -\frac{13.6}{9} = -1.51\text{ eV etc.}$$

33. (*c*) The wavelength of a spectral line for an electronic transition is inversely proportional to the difference in the energies involved in the transition.

$$\Delta E = E_2 - E_1 = \frac{hc}{\lambda}$$

$$\lambda \propto \frac{1}{\Delta E}$$

34. (*d*) 1s electronic level would allow a hydrogen atom to absorb a photon but not to emit it.

On absorption of radiation, electron will be transferred from 1s level to higher levels such as 2s or 3s. But to emit a photon, the electron should go to the lower energy level from a higher energy level. Since 1s is the lowest energy level, the electron cannot go to a lower level. Hence, emission of photon is not possible.

35. (*c*) $r = 0.529\times\frac{n^2}{z} \Rightarrow r \propto n^2$ $\Rightarrow$ (I)

$mvr = \frac{nh}{2\pi} \Rightarrow (mrv) \propto n$ $\Rightarrow$ (II)

$KE = +13.6\times\frac{z^2}{n^2} \Rightarrow KE \propto n^{-2}$ $\Rightarrow$ (III)

$PE = -2\times13.6\times\frac{z^2}{n^2} \Rightarrow PE \propto n^{-2}$ $\Rightarrow$ (IV)

36. (*d*) Conceptual

37. A $\rightarrow$ (r); B $\rightarrow$ (q) ; C $\rightarrow$ (p) ; D $\rightarrow$ (s)

(A) $V_n = -\frac{1}{4\pi\epsilon_0}\left(\frac{Ze^2}{r}\right)$

$$\Rightarrow \frac{V_n}{K_n} = -2$$

(B) $E_n = -\frac{Ze^2}{8\pi\epsilon_0 r}$

$E_n = \propto r^{-1}$

(C) Angular Momentum $= \sqrt{\ell(\ell+1)}\frac{h}{2\pi} = 0$ is 1s orbital. As $\ell = 0$ for 1s.

(D) $r_n = \frac{a_0n^2}{z} \Rightarrow \frac{1}{r_n} \propto Z$

So, y = 1

38. [30] As we know that, for a single electron system. we have

$$r = 52.9\times\frac{n^2}{Z}\text{pm}$$

Given Z = 2 for He^+

$r_2 = 105.8$ ppm

Thus, $105.8 = 52.9\times\frac{n_2^2}{2}$

$n_2 = 2$

$r_1 = 26.45$

So $26.45 = 52.9\times\frac{n_1^2}{2}$

$n_1 = 1$

Hence, transition is from 2 to 1.

As $\frac{hc}{\lambda} = R_H Z^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

On solving, $\lambda = 30\times10^{-9}$ m = 30 nm

39. [–5242.4192] Given that, electrons and nucleus are at infinite distance, so potential energy of H-atom is taken as zero.

Therefore, according to Bohr's model, potential energy of a H-atom with electron in its ground state = 27.2 eV

At d = d_0, nucleus-nucleus and electron-electron repulsion is absent.

Hence, potential energy will be calculated for 2H atoms = –2 × 27.2 eV = –54.4 eV

Potential enery of 1 mol H atoms in kJ

$$= \frac{-54.4\times6.02\times10^{23}\times1.6\times10^{-19}}{1000}$$

= –5242.4192 kJ/mol

40. [1:16] Kinetic energy of a gas at fixed temperature T is given by the expression:

$$KE = \frac{3}{2}nRT = \frac{3}{2}\times\frac{W}{M}RT$$

Here, n is the no. of moles of gas, W is the mass of gas and M is the molar mass of a gas. Thus, the kinetic energy of gas molecules is inversely proportional to the molar mass of gas molecules.

$$\frac{K.E_{O_2}}{K.E_{H_2}} = \frac{X}{y} = \frac{M_{H_2}}{M_{O_2}} = \frac{2}{32} = \frac{1}{16}$$

Hence the ratio is 1:16.

41. (*a*) The velocity of electron in Bohr's orbit is given as follows:

$$mvr = \frac{nh}{2\pi}$$

$$\Rightarrow v = \frac{nh}{2\pi mr}$$

$$= \frac{6.625\times10^{-34}}{2\times3.14\times9.1\times10^{-31}\times0.529\times10^{-10}}$$

The de-Broglie wavelength is given as follow:

$= 2.18\times10^{6}\ ms^{-1}$

(*b*)

$$\lambda = \frac{h}{p} = \frac{6.625\times10^{-34}}{9.1\times10^{-31}\times2.18\times10^{6}} \quad (\because p = mv)$$

$= 0.33\times10^{-9}$ m

(*c*) Orbital angular momentum

For 2p orbital the value of $\ell = 1$ So,

$$(L) = \sqrt{\ell(\ell+1)}\frac{h}{2\pi} = \sqrt{2}\left(\frac{h}{2\pi}\right)$$

$$= \sqrt{2}\left(\frac{h}{2\pi}\right)$$

42. For maximum energy, $n_1 = 1$ and n_2 = infinite

$1/\lambda = R_H(1/n_1^2 - 1/n_2^2)Z^2$

Since R_H is a constant and transition remains the same

$1/\lambda$ is directly proportional to Z^2

Hence, $\frac{1}{\lambda} \propto Z^2$

$$\frac{1}{\lambda_H} \propto Z_H^2$$

and $\frac{1}{\lambda_{He}} \propto Z_{He}^2$

or $\frac{\lambda_{He}}{\lambda_H} = \frac{Z_H^2}{Z_{He}^2}$

Given, that $\lambda_H = 91.2$ nm and we know that $Z_H = 1$ and $Z_{He} = 2$

$$\therefore \frac{\lambda_{He}}{91.2} = \frac{1^2}{2^2}$$

or $\lambda_{He} = \frac{91.2\times1^2}{2^2} = \frac{91.2}{4} = 22.8$nm

Corresponding wavelength of He-atom $(\lambda_H) = 22.8$ nm

Hence, $\lambda_{He} = 1/4\times91.2 = 22.8$ nm

43. Determination of number of moles of hydrogen gas,

$$N = \frac{PV}{RT} = 1\times\frac{1}{0.082}\times298 = 0.0409$$

The concerned reaction is $H_2 \rightarrow 2H$, $\Delta H = 436$ kJ / mol

Energy required to bring 0.0409 moles of H gas to atomic state

$= 436\times0.0409 = 17.83$ kJ

1 mole of H_2 gas has 6.022×10^{23} molecules

Since, 1 molecule of H_2 gas has 2H atom

$= 6.022\times10^{23}\times0.0409$

$= 2\times6.022\times10^{23}\times0.0409 = 4.92\times10^{22}$ atoms of H.

$$E = 13.6\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)\text{eV} = 13.6\times\left(\frac{1}{1} - \frac{1}{4}\right)$$

$$= 13.6\times\frac{3}{4} = 10.2\text{eV}$$

$= 1.632\times10^{-18}$ kJ

Therefore, energy required to excited 4.92×10^{22} electrons

$= 1.632\times10^{-18}\times4.92\times10^{22}$ kJ

44. The kinetic energy of alpha particle will be equal to potential energy, so

$$\frac{1}{2}mu^2 = \frac{1}{4\pi\epsilon_0}\times\frac{2ze^2}{r}$$

$$u^2 = \frac{4z^2}{4\pi\epsilon_0.m.r}$$

$$= \frac{29\times(1.6\times10^{-19})^2}{3.14\times8.85\times10^{-12}\times(4\times1.672\times10^{-27})\times10^{-10}}$$

$= 6.3\times10^{6}$ m/sec

Hence, the velocity of an alpha particle is 6.3×10^{6} m/sec.

45. In the process of charge neutralisation the work done is given as

$$W = -\int_{a_0}^{\infty}Fdr,\ F = \frac{e^2}{4\pi\epsilon_0r^2}$$

$$\text{Hence, } W = \frac{e^2}{4\pi\epsilon_0r^2}$$

[This is equal to E (Total energy)]

Now, TE = PE + KE $\left[\therefore KE = \frac{PE}{2}\right]$

$$\text{Hence, } TE = -PE + \frac{PE}{2}$$

$$PE = -2\times TE = -2\times\frac{e^2}{4\pi\epsilon_0a_0}$$

$$PE = \frac{-e^2}{2\pi\epsilon_0a_0}$$

46. No. of waves made by Bohr's electron in one complete rotation, $n = \frac{2\pi r}{\lambda}$.

$\because mvr = \frac{nh}{2\pi}$

$\therefore 2\pi r = \frac{nh}{mv} = n\lambda \left[\because \lambda = \frac{h}{mv}\right]$

$\therefore$ no. of waves = n = 3 [n = 3 for required orbit.]

We know that

No. of waves

$= \frac{\text{Circumference of electron orbit}}{\text{Wavelength}}$

$= \frac{2\pi r}{\lambda}$

Now, substitute the value of λ in this equation to calculate the number of waves.

$\therefore$ Number of waves $= \frac{2\pi r}{\frac{2\pi r}{3}} = 3.$

47. E_1 for H = – 13.6eV

$\therefore E_2$ for H = $(-13.6/2^2) = -13.6/4 = -3.4$ eV

$\therefore E_2 - E_1 = -3.4 - (-13.6) = +10.2$ eV

Also, for transition of H like atom; $\lambda = 3.0 \times 10^{-4}$ m

$\frac{1}{\lambda} = R_H Z^2 \left[\frac{1}{1^2} - \frac{1}{2^2}\right]$

$\frac{1}{3\times10^{-4}} = 1.09\times10^7 \times Z^2 \times \frac{3}{4}$

$\therefore Z^2 = 4$ and $Z = 2$

Thus, the H like atom is He^+

48. The electronic energy of He^+ ion in the nth Bohr's orbit

$= -\frac{21.7\times10^{-19}}{n^2} \times Z^2 J$

where, Z = 2

Thus, energy of He^+ in the 3rd Bohr orbit

$= -\frac{21.7\times10^{-19}}{9} \times 4J$

$\Delta E = E_\infty - E_3$

$= 0 - \left[-\frac{21.76\times10^{-19}\times4}{9}\right]$

$= \frac{21.76\times10^{-19}\times4}{9}$

We know that, $\lambda = \frac{hc}{\Delta E}$

$= \frac{6.625\times10^{-34}\times3\times10^8\times9}{21.76\times10^{-19}\times4} = 2.055\times10^{-7}$ m

49. $E = -\frac{21.7\times10^{-12}}{n^2}$ erg

Electron energy in the 2nd orbit, i.e., n = 2,

$E_2 = -\frac{21.7\times10^{-12}}{2^2}$ erg $= -5.425\times10^{-12}$ erg

and $E_\infty = 0$

ΔE = Change in energy = $E_\infty - E_2 = 5.425 \times 10^{-12}$ erg.

Thus, energy required to remove an electron from 2nd orbit = 5.425×10^{-12} erg

According to quantum equation,

$\Delta E = h \cdot \frac{c}{\lambda}$

($h = 6.625 \times 10^{-27}$ erg – sec; $c = 3 \times 10^{10}$ cm/sec)

and $\Delta E = 5.425 \times 10^{-12}$ erg

So, $\lambda = \frac{(6.625\times10^{-27})\times(3\times10^{10})}{5.425\times10^{-12}}$

$= 3.7 \times 10^{-5}$ cm.

50. $E_2 - E_1 = -2.17\times10^{-11}\left[\frac{1}{4} - \frac{1}{1}\right]$ erg

$[n_1 = 1, n_2 = 2]$

$= 2.17\times10^{-11} \times \frac{3}{4}$ erg

$E_2 - E_1 = h\nu = \frac{c}{\lambda}h$

$\lambda = \frac{hc}{\Delta E} = \frac{6.62\times10^{-27}\text{erg}\times3.0\times10^{10}\text{cm}}{2.17\times10^{-11}\times3/4}$

$= \frac{2.648}{2.17}10^{-5}$ cm

$= 1.22 \times 10^{-5}$ cm = 1220 A°

51. Transition energy,

$= [-2.41 - (-5.42)] \times 10^{-12}$ erg

$= 3.01 \times 10^{-12}$ erg

$= 3.01 \times 10^{-19}$ J $\quad [\because 1 \text{ erg} = 10^{-7} \text{ J}]$

Also, $\Delta E = \frac{hc}{\lambda}$

$\Rightarrow \lambda = \frac{6.625\times10^{-34}\times3\times10^8}{3.01\times10^{-19}}$ m

$= 660 \times 10^{-9}$ m = 660 nm

52. (c) The wavelength associated with a golf ball is

$\lambda = \frac{h}{mv}$

From question m = 200 g = 0.2 kg

Speed v = 5 m/h = $\frac{5}{3600}$ ms

Now, $\lambda = \frac{6.626\times10^{-34}}{0.2\times\frac{5}{3600}} = 2.4\times10^{-36}$ m

53. [30] $\lambda = \frac{h}{m(\Delta v)}$

$330\times10^{-9} = \frac{6.6\times10^{-34}}{\left(\frac{4\times10^{-3}}{6\times10^{23}}\right)\times\Delta v}$

$\Delta v = \frac{6.6\times6\times10^{23}\times10^{-34}}{4\times10^{-3}\times330\times10^{-9}} = 30$ cm/s

54. (Heisenberg and De Broglie)

55. For an electron $\frac{1}{2}mv^2 = eV$; also $\lambda = \frac{h}{mv}$

$\therefore \frac{1}{2}m\frac{h^2}{m^2\lambda^2} = eV$

$V = \frac{1}{2}\frac{h^2}{m\lambda^2 e}$

$V = \frac{1\times(6.626\times10^{-34})^2}{2\times9.108\times10^{-31}\times(1.54\times10^{-10})^2\times1.602\times10^{-19}}$

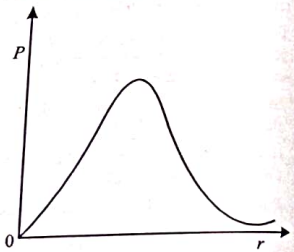
= 63.44 volt.

56. (c) Radial probability function curve for 1s

Here P is $4\pi r^2R^2$

The waves in the given graphs depicts the probability density, meaning the orbital where the probability of finding an electron is maximum. For 1s orbital, the probability of finding an electron will be maximum at the nucleus, as 1s orbital is the nearest to the nucleus and it has lowest energy.

Therefore, the radial probability curve which shows a peak at the nucleus will have the maximum probability with respect to the radius. The curve is -



57. (a) The number of radial nodes of 3s and 2p orbitals are 2 and 0 respectively.

Number of radial nodes = n – l – 1, where l = 0 for s orbital and l = 1 for p orbital.

For 3s orbital, number of radial nodes,

= 3 – 0 – 1 = 2

For 2p orbital, number of radial nodes,

= 2 – 1 – 1 = 0

58. (c) Pauli's exclusion principle states that the orbitals are filled in the increasing order of the energy shell e.g. $1s^22s^22p^63s^23p^6$. This configuration violates Pauli's exclusion principle as one orbital cannot have more than two electrons.

59. (d) The quantum numbers $+\frac{1}{2}$ and $-\frac{1}{2}$ for the electron spin represent two quantum mechanical spin states which have no classical analogue.

There are two non-classical quantum mechanical spin states.

Similar to how the earth revolves around the sun while spinning on its own axis, an electron too revolves around its own axis. In other words, an electron possesses inherent spin angular quantum number in addition to charge and mass. The electron's spin angular momentum can be oriented in one of two directions with respect to the selected axis. The spin quantum numbers, which might have values of $+\frac{1}{2}$ or $-\frac{1}{2}$, serve to differentiate these two orientations.

There is no classical analogue to electron spin.

60. (a) Nodal plane is an imaginary plane on which the probability of finding an electron is minimum. P-orbital has 3 nodal planes. one is of p_x another one is of p_y and the last one is of p_z.

Therefore, we conclude that P_x has 1 nodal plane.

61. (b) The electron configuration of an atom shows the number of electrons in each sublevel in each energy level of the ground state atom.

Here, $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^5\ 4s^1$ is ground state electronic configuration of Cr.

62. (a) According to the (n + ℓ) rule, the lower the value of (n + ℓ) for an orbital, the lower its energy. The orbital with the lower n number has less energy if two orbitals have the same (n + ℓ) value.

As a result, the growing electron energy sequence is maintained (iv) (ii) (iii) (i)

63. (a) We know that the orbital angular momentum (L) = $\sqrt{\ell(\ell+1)}\frac{h}{2\pi}$

For d - orbital, ℓ = 2

Thus, the orbital angular momentum is

$\sqrt{6}\frac{h}{2\pi}$

64. (b) For s-orbital ℓ = 0, now orbital angular momentum,

$= \sqrt{\ell(\ell+1)}\frac{h}{2\pi} = \sqrt{0(0+1)}\frac{h}{2\pi} = 0$

65. (c) The most electronegative element is Fluorine whose electronic configuration is $2s^2\ 2p^5$.

66. (c) The E.C. of Cl (Z=17) is given as follow:

$_{17}Cl = 1s^22s^22p^63s^23p^5$

It has only one unpaired e^- parent 3p orbital.

Hence, n = 3, ℓ = 1 and m can have any of the there value (–1, 0, +1)

67. (a) The ground state electronic configuration of chromium atom is $[Ar]3d^5\ 4s^1$.

68. (b) The orbital diagram in which 'aufbau principle' is violated, is represented by the option (b).

Aufbau principle:

In the ground state of the atoms, the orbitals are filled with electrons in order of increasing energy.

The 2s sub-energy level is at a lower energy than the 2p sub-energy level

For 2s, n = 2 and (ℓ = 0)

Hence, (n + ℓ) = 2 + 0 = 2

For 2p, n = 2 and (ℓ + 1)

Hence, (n + ℓ) = 2 + 1 = 3

As the value of (n + 1) for 2s orbital is less than that of 2p orbital, 2s orbital is filled before 2p orbital.

69. (c) n = 3, l = 2, m = –3, s = 1/2 represents an impossible arrangement.

When l = 2, m cannot be equal to – 3.

For a given value of l, m can have values –1,.....0....+1.

70. (a) Electronic configuration of Rubidium is (Z = 37) =

$1s^22s^22p^63s^23p^64s^23d^{10}4p^65s^1$

The valence electron is in 5s orbital.

For 5s orbital

n = 5 , l = 0, m = 0 and s = $+\frac{1}{2}$

Its 4 quantum numbers are - n = 5, ℓ = 0, m = 0, s = $+\frac{1}{2}$

71. (a) The principal quantum number 'n' represents orbit number hence, determines the size of orbitals. The principal quantum numbers are represented by the letters 'K, L, M, N' or equal to 1, 2, 3, 4, etc.

The maximum number of electrons that can accommodate in a principal energy shell is given by $2n^2$.

72. (d) Any orbital can accommodate a maximum of 2 electron with opposite spin so p - orbital can have 2 electrons with opposite spin.

73. (a,b,c)

(a) The existence of definite paths or trajectories of electron and other similar particles is ruled out by Uncertainty principle.

So, option (a) is correct.

(b) A closer orbit or shell around the nucleus has less energy than a farther oribit

So, option (b) is also correct.

(c) $E = -13.6\frac{Z^2}{n^2}$ eV / atom

So, n = 1 has most negative energy.

So, option (c) is also correct.

(d) $V = V_0 \times \frac{Z}{n}$

when n increases velocity decreases.

So, option (d) is incorrect.

74. (a, c) Given, ground state energy of hydrogen atom = –13.6 eV

Energy of He^+ = – 3.4 eV, Z = 2

Energy of He^+, $E = -\frac{13.6\times Z^2}{n^2}$ eV

$-3.4 \text{ eV} = \frac{-13.6\times(2)^2}{n^2} \Rightarrow n = \sqrt{\frac{13.6\times4}{3.4}}$

$\Rightarrow n = 4$

Given, azimuthal quantum number (ℓ) = 2 d–subshell

Magnetic quantum number (m) = 0

∴ Angular nodes (ℓ) = 2

Radial node = n – l – 1 = 4 – 2 – 1 = 1

nl = 4d state

Hence, options (a), (c) are correct.

75. (a, d) Ground state electronic configuration of nitrogen atoms can be represented by (a) and (d) only.

All the unpaired electrons have spins aligned in the same direction only.

76. (a, b, c) The statements a, b and c are correct. The statement d is incorrect.

(a) Electronic configuration of Cr is $[Ar]3d^5\ 4s^1$ (Atomic number of = 24). Both 3 d and 4 s orbitals are half filled. This leads to extra stability.

(b) The magnetic quantum number may have negative value.

Thus, when l = 2, m = – 2, –1, 0, + 1, + 2

(c) In silver atom, 23 electrons have a spin of one type and 24 of the opposite type

(Atomic number of Ag = 47). It has one unpaired electrons and 23 electron pairs.

Two electrons in an electron pair have opposite spin.

The oxidation state of nitrogen in HN_3 is $-\frac{1}{3}$

Let x be the oxidation number of nitrogen in HN_3. The oxidation number of H is +1.

77. (c) Be = $1s^2\ 2s^2$, it has stable electronic configuration. Removal of electron from stable configuration requires large energy, which in case of Boron B(s) = $1s^2\ 2s^2\ 2p^1$ it is easy to remove e^- from 2p orbitals.

Hence statement-I is correct.

Now according to Aufbau principle 2p orbital has higher energy than 2s.

Hence, statement-II is incorrect.

78. (b) 2s is symmetrical having one radial node.

79. (c) S_2 state spherical symmetrical means $l = 0$

Number of nodal points $= 1(n - l - 1) = 1$

$(n - 0 - 1) = 1 \therefore n = 2$

Hence 2 s orbital corresponds to S_1 state

S_2 state has only one radial node and E = ground state of H atom

$E_{H_1^1} = \frac{R}{1^2}$ (for ground state)

E in S_2 state $Li^{2+} = -\frac{R}{1^2}$ (but this is equal $\frac{Z^2}{n^2} \times R$) Since Z = 3 for Li^{2+} ion

$\therefore n = 3$

Since it has only one radial node:

$(n - l - 1) = 1, \Rightarrow (3 - 1 - 1), \therefore l = 1$

Therefore, S_2 state corresponds to $3_p (n = 3, l = 1)$

$E \text{ of } S_2 \text{ state} = \frac{RZ^2}{n^2} = R \times \frac{3^2}{2^2} = \frac{9}{4}R = 2.25R$

$2.25 \times E_{H_1^1}$ in ground state.

80. (b) The spherically symmetric state S_1 of Li^{2+} with one radial node is 2s. Upon absorbing light, the ion gets excited to state S_2, which also has one radial node. The energy of electrons in S_2 is the same as that of the energy of electrons in the ground state Hydrogen atom.

Since Z = 3 for Li^{2+} and $E_n = E_1$, where E_1 is the energy for ground state H-atom.

$\therefore \frac{3^2}{n^2} 13.6 = 13.6$

$\Rightarrow n = 3$

Thus, the state S_2 of Li^{2+} having one radial node is 3p.

Orbital angular momentum quantum number of 3p is 1.

Hence option (b) is correct.

81. (c) 1s orbital is non-directional. So Ψ will not depend upon cos θ. Hence (c) is incorrect.

82. (a) For H-like species only (a) is correct because-

For 1s orbital has no radial node.

For $3d_z^2$, xy plane is not nodal plane.

For $2p_z$ orbital has no radial node.

83. (d) For M-atom is orbital

$$\Psi \times \left(\frac{z}{a_0}\right)^{\frac{3}{2}} e^{-\left(\frac{r}{a_0}\right)}$$

Also, $E_4 - E_2 = \frac{3}{16}$

$E_6 - E_2 = \frac{2}{9}$

Hence, $(E_6 - E_2) \times \frac{27}{32} = (E_4 - E_2)$

Correct option should be (d).

84. [3] Single electron species don't follow the Hund's rule and all orbitals of a particular shell have the same energy and are called degenerate orbitals.

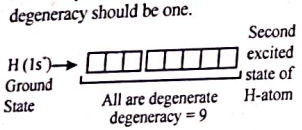
Therefore, second excited state of H(n = 3) will have

9 orbitals of same energy i.e; degeneracy = 9

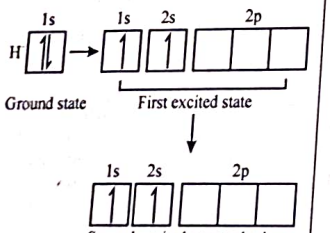
Ground state of $H^- = 1s^2$

First excited state of $H^- = 1s^1, 2s^1$

In first excited state of multi electron species have only one energy states, hence the degeneracy should be one.



In case of many electrons system, different orbitals of a shell are non-degenerate. Hence,



85. [6] For n = 4, $|m_l| = 1$ means the value of $m_l = \pm 1 (+1 \text{ and } -1)$ for $m_l = -1$ and +1, there are total 6 orbital, and each orbital contains maximum two electron with opposite spin $[+Y_2 \text{ and } -Y_2]$. Hence, there are 6 electrons which have $|m_l| = 1$ and $m_s = -\frac{1}{2}$

Final Answer = 6

86. [9] For n = 3, l = 0, 1, 2, means there are 3s, 3p and 3d orbitals suppose all orbitals are completely occupied

$3s^2$, $3p^6$ and $3d^{10}$, so total $18e^-$, out of these 9 electron have $+\frac{1}{2}$ spin and other have $-\frac{1}{2}$ spin.

Final Answer = 9

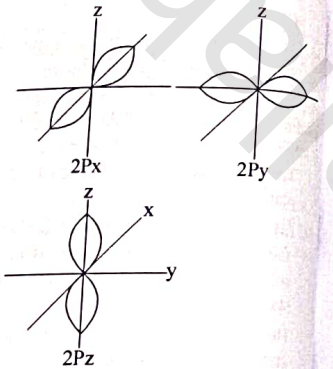
87. ([Ar]$3d^5 4s^1$) Chromium has an atomic number of 24 with an outer configuration of $4s^1 3d^5$.

88. (orbital) Wave functions of electrons in atoms and molecules are called orbitals.

An orbital is a three-dimensional space around the nucleus in which the probability of finding an electron is maximum. An orbital can accommodate only 2 electrons.

89. (orientation in space) The $2p_x$, $2p_y$, $2p_z$ have similar shapes but differ in their orientation. The diagram representation is given below.

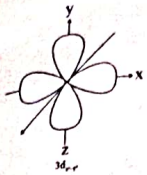
Also, all three of them have the same energy level.



90. (Opposite) When there are two electrons in the same orbital, they have opposite spins. The Pauli exclusion principle states that there can only be a maximum of two electrons for every one orientation, and the two electrons must be opposite in spin direction; meaning one electron has $m_s = +\frac{1}{2}$ and the other electron has $m_s = -\frac{1}{2}$

91. (FALSE)

Since, in $3dx^2 - y^2$ lobes lies along x and y axis. therefore it's electron density in the x – y plane is non-zero.



92. (TRUE)

The energy of the orbitals in hydrogen atom increases as follows:

$1s < 2s = 2p < 3s = 3p = 3d < 4s = 4p = 4d = 4f < .....$

93. (FALSE) The given configuration of Cr: $3d^4 4s^2$ is wrong. False statement.

The outer electronic configuration of the ground state chromium atom must be Cr : $3d^5 4s^1$. (Its exceptional from the normal configurations)

94. (a) $\Psi^2 = 0$ for radial nodes

$$\Psi_{2s}^2 = 0 = \left[\frac{1}{4\sqrt{2\pi}}\right]^2 \left(2 - \frac{r_0}{a_0}\right)^2 e^{-\frac{r_0}{a_0}}$$

$$\Rightarrow 2 - \frac{r_0}{a_0} = 0 \Rightarrow r_0 = 2a_0$$

(b) The wavelength associated with base ball is given by

$$\lambda = \frac{h}{mv} = \frac{6.625 \times 10^{-34}}{100 \times 10^{-3} \times 100} = 6.625 \times 10^{-35} \text{ m}$$

$= 6.625 \times 10^{-25}$ Å (negligibly small)

95. The given principal quantum number is 3, that means it is the 3rd shell.

The azimuthal quantum number is 2, that means in the d orbital.

This is because,

0 → s - orbital

1 → p - orbital

2 → d - orbital and so on

So, now find the number of electrons present in 3d orbital.

The principal quantum number doesn't affect the number of electrons present in an orbital. So, ultimately, the number of electrons present in 3d = number of electrons present in d orbital = 10.

Thus, the 3d - orbital contains 10 electrons.

96. Is in accordance with Hund's rule which states that electron pairing in any orbital (s, p, d, f) cannot take place until each orbital of the same sub-level contain one electron each of same spin.

Physics Walah